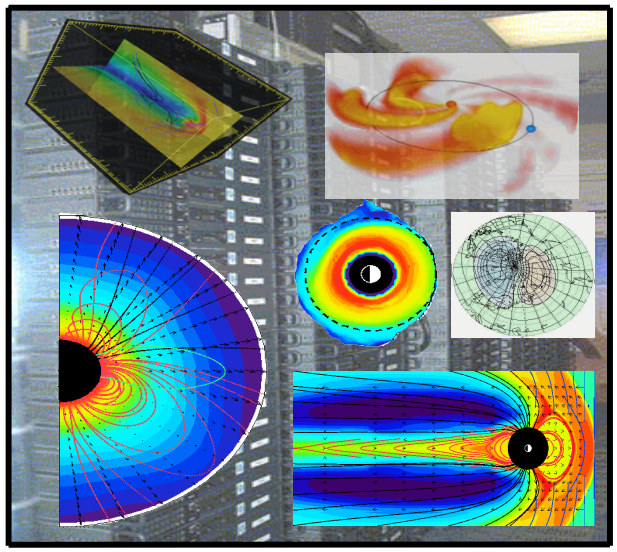
CCMC/SWRC Models, Tools, Services

Yihua Zheng

NASA Goddard Space Flight Center



Based on the materials presented by Masha @ previous Heliophysics Summer School

http://ccmc.gsfc.nasa.gov

http: //ccmc.gsfc.nasa.gov

CCMC mission statement

The CCMC is a multi-agency partnership to enable, support and perform the research and development for next-generation space science and space weather models.

Space Weather Research, Education and Development Initiative (SW REDI)

UPCOMING EVENT: SW REDI Boot Camp (June 3-15, 2013)

The 2-Week Intense Space Weather Training camp at NASA Goddard is a part of our CCMC/SWRC Space Weather Research, Education and Development Initiative (SW/REDI).

The foundation of this camp/course includes the in-house Integrated Space Weather Analysis system (iSWA; http://iswa.gsfc.nasa.gov), space environment models installed at the CCMC, and the operational experience of the SWRC team (http://swrc.gsfc.nasa.gov).

The goals of the SW REDI are:

- Promote space environment awareness as an important component of the new millennium core education.
- Facilitate establishment of space weather programs at universities worldwide.
- Provide undergraduate student internship opportunities at CCMC/SWRC to develop skills beneficial for any future career pursuit.

Click here for details

Student Research Contest

The Community Coordinated Modeling Center and National Science Foundation are pleased to announce the second annual CCMC Student Research Contest.

CCMC Services

- We provide, to the scientific community, access to modern space resear
- We test and evaluate models
- We support Space Weather forecasters
- We support space science education

Latest additions to the CCMC services

- **Integrated Space Weather Analysis System** is a web-based disse NASA-relevant space weather information.
- **Space Weather Awareness at NASA** space weather information pc
- **LWS Supported Tools and Methods**
- **Kameleon software**: model output from different models can now b common science data format. Users can request the CDF-formatted ou
- **Movies on Request**: you can now request to generate a movie, image time step of a model run.
- **CCMC Space Weather on Google Earth**: CCMC is now providing s Earth overlays.

Model additions/updates at the CCMC

- **PREDICCs is now available for Real-Time runs**
- **OpenGGCM new version 4.0 is now available for Runs-On-Re (Dipole Update)**

Educational Materials On CCMC Web

Educational materials

CCMC Student Research Contest

Illustrating space science using CCMC runs

Educational materials created by G.Siscoe on the basis of CCMC runs.

- Properties of Magnetic Dipoles
- Modules on Magnetospheric Physics
- Database of general purpose runs for education and research

Space Weather Research, Education and Development Initiative (SW REDI)

Heliophysics Summer Schools

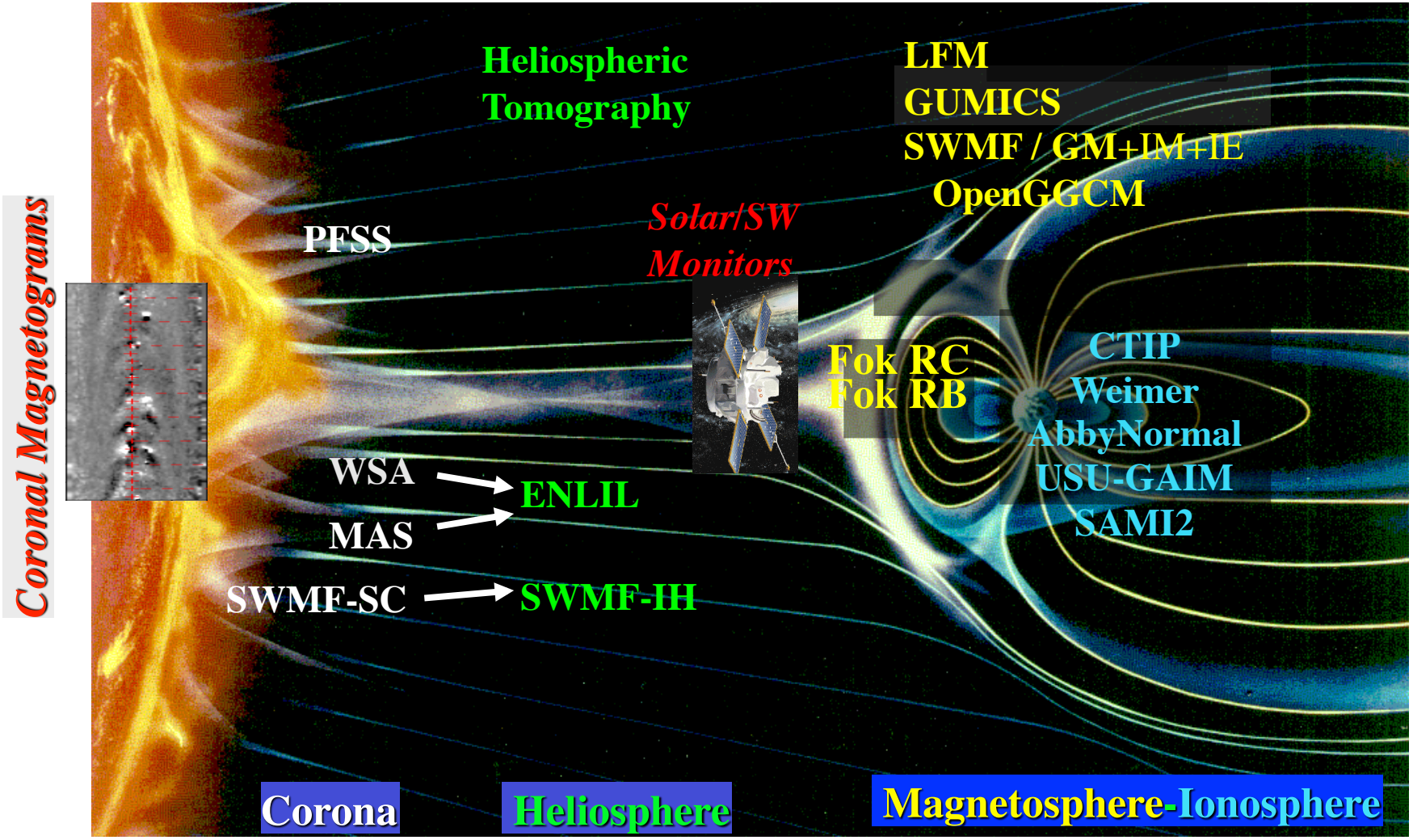
- Heliophysics Summer School 2012
- Heliophysics Summer School 2011
- Heliophysics Summer School 2010
- CCMC user help

Repository of educational materials

- CUA Space Weather Academy space weather tutorials *by Antti Pulkkinen*
- Images and Movies
- Glossary

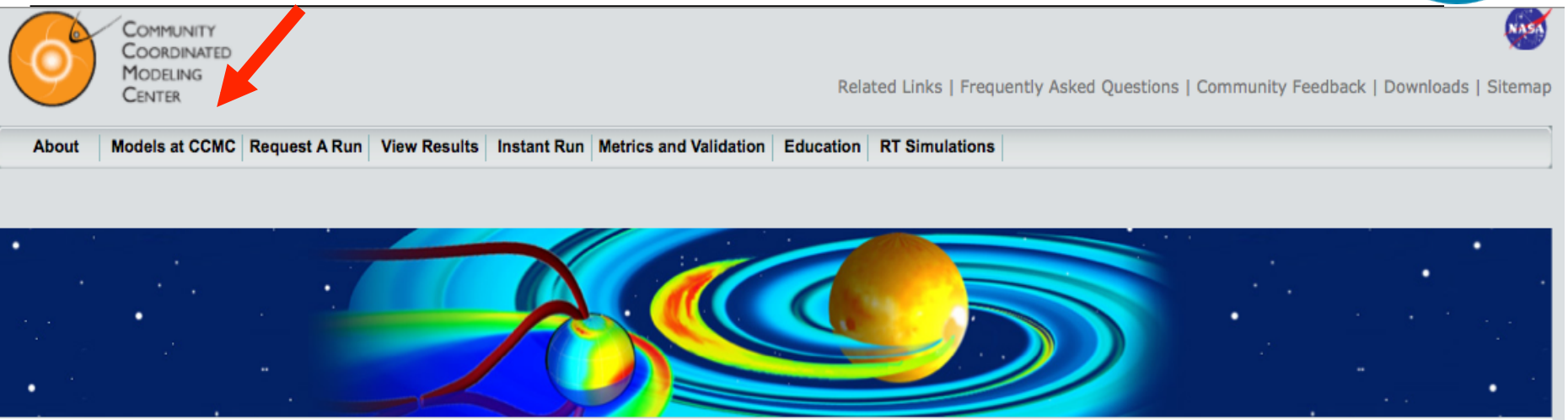
CCMC Tutorial at CEDAR

CCMC Models Cover the Entire Domain

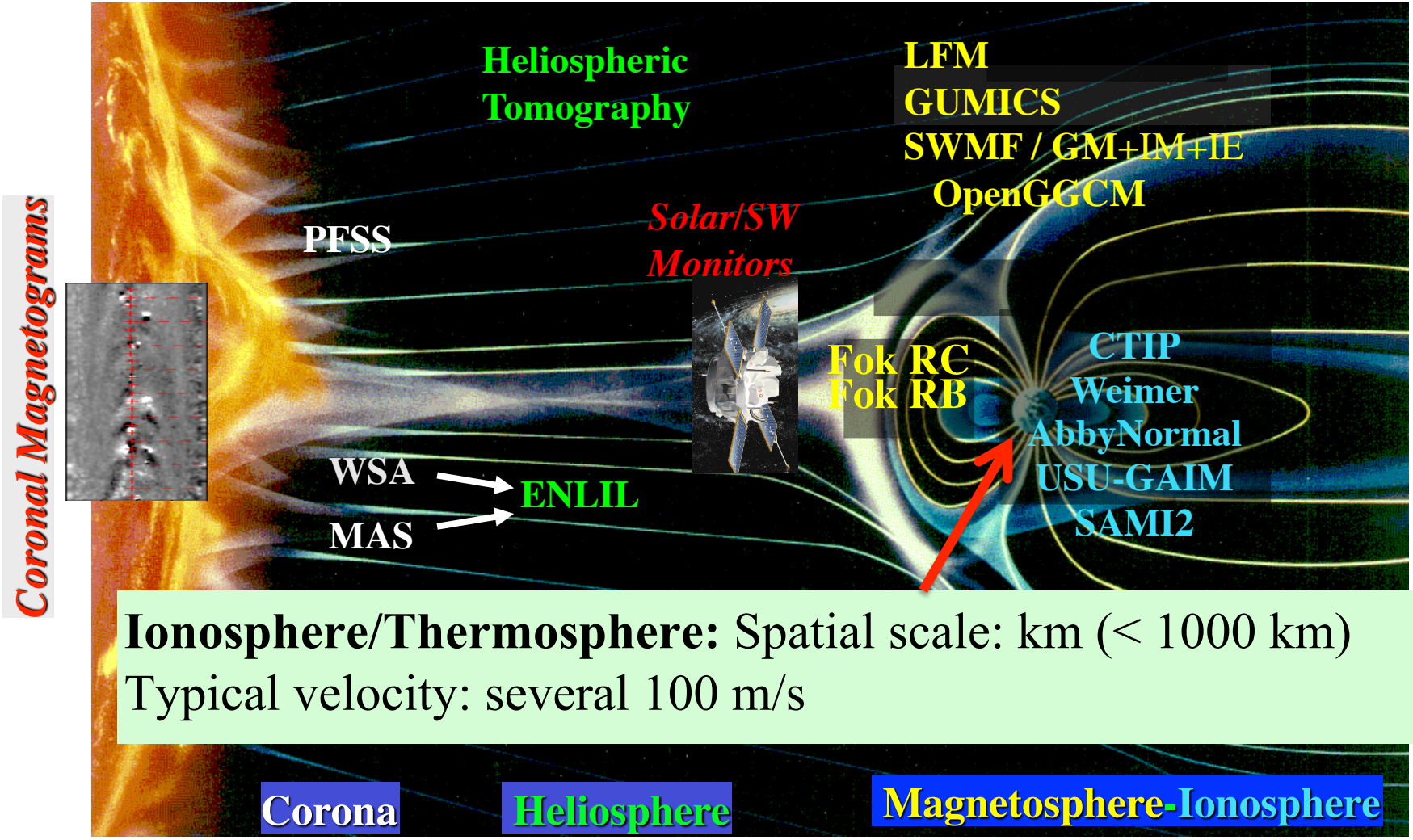


http: //ccmc.gsfc.nasa.gov

Here

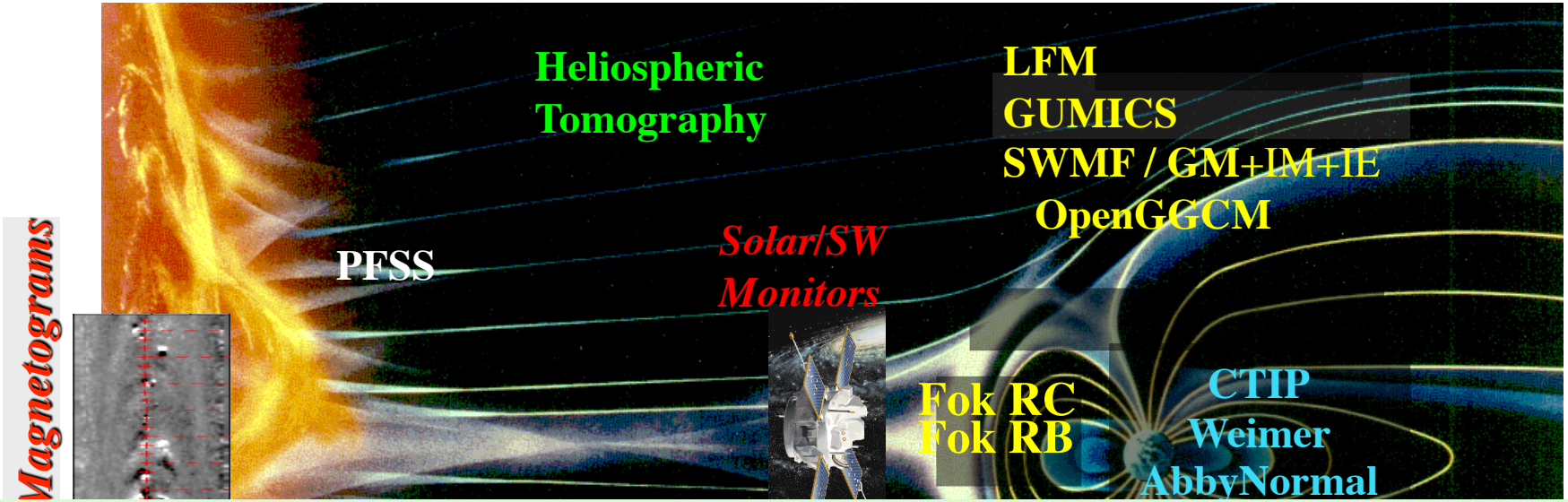


CCMC Models Cover the Entire Domain



Ionosphere/Thermosphere: Spatial scale: km (< 1000 km)
Typical velocity: several 100 m/s

CCMC Models Cover the Entire Domain



Magnetosphere: Spatial scale: 1 R_E (Earth's radius) = 6370 km
Typical velocity: several 100 km/s

L1 (Solar Wind Monitor ACE location, also SOHO): ~ 200 R_E sunward

Global MHD simulation domain (30 R_E (dayside) < X < - 100 R_E (tail)
Inner boundary ~ 3R_E (around the Earth)

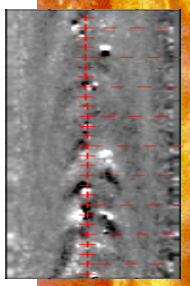
Rig Current / Radiation Belt (Inner magnetosphere): 2 R_E < R < 8 R_E

CCMC Models Cover the Entire Domain

L1 (Solar Wind Monitor ACE location): ~ 200 R_E sunward

Solar Corona: 1 – 20 R_S
1 R_S (solar radius) ~ 110 R_E

Heliosphere: 2 – 10 AU
1 AU ~ 215 R_S



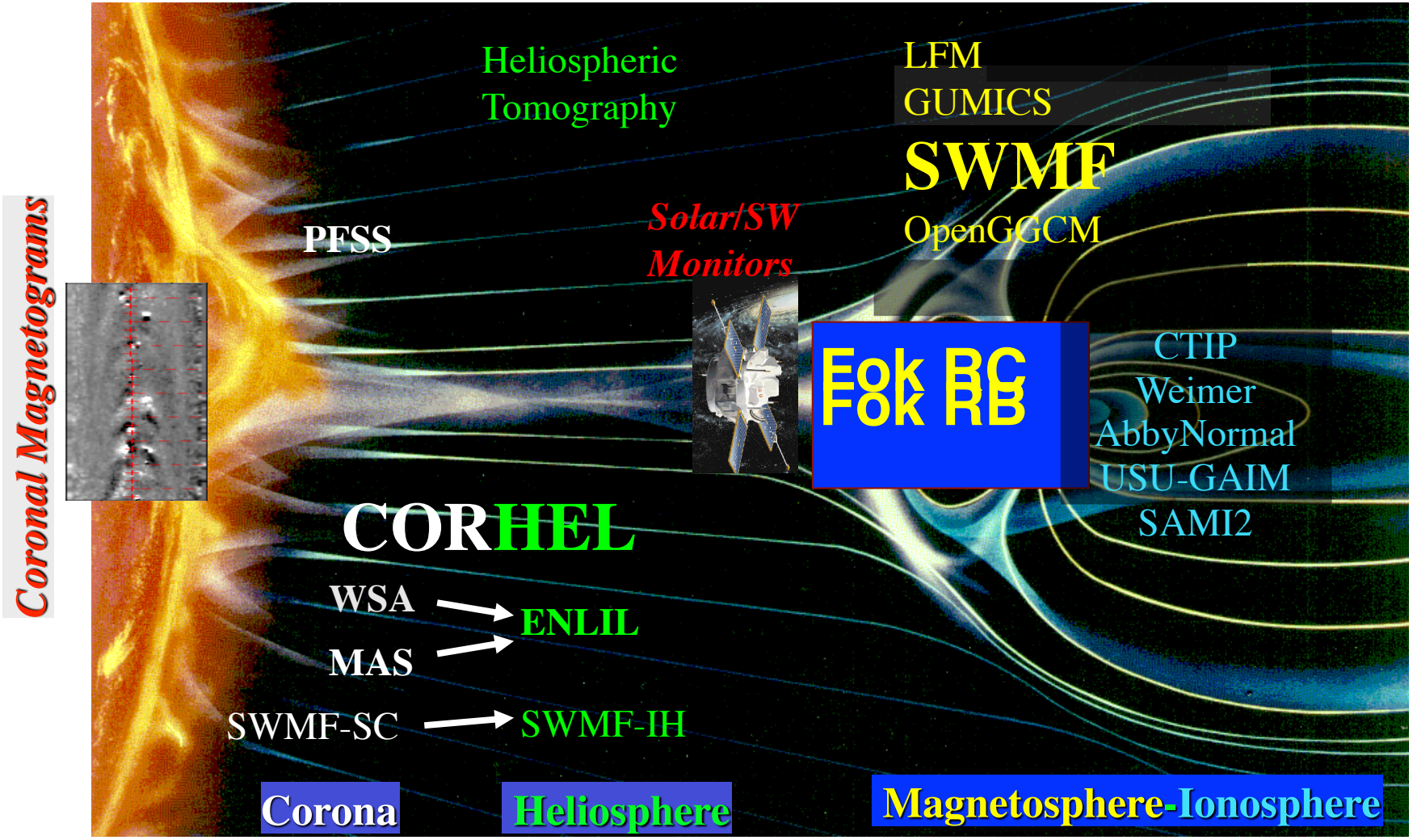
Coronal Magnetograms

WSA → ENLIL
MAS →
SWMF-SC → SWMF-IH

AbbyNormal
USU-GAIM
SAMI2

Corona | Heliosphere | Magnetosphere-Ionosphere

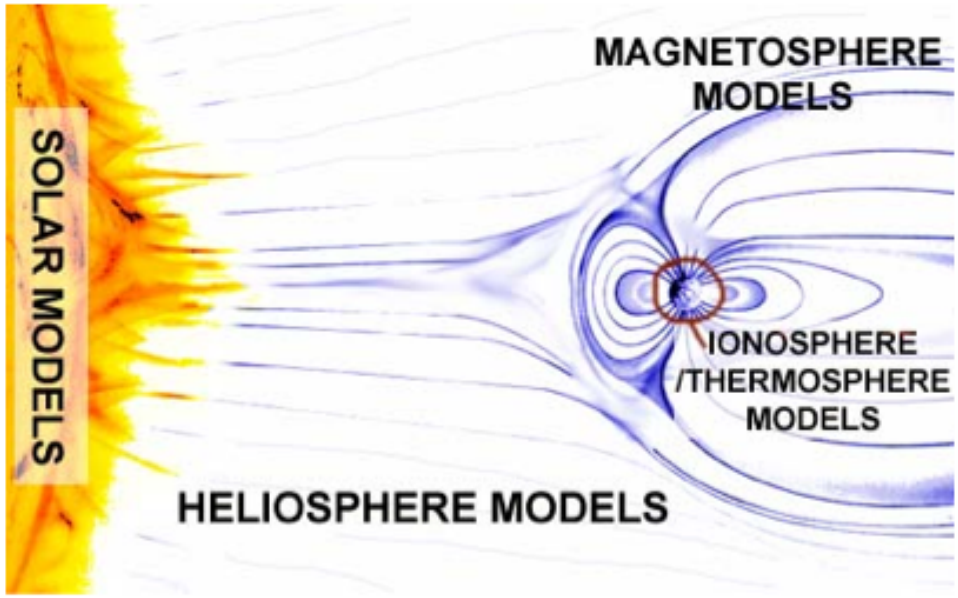
CCMC Models Cover the Entire Domain



CCMC Tools and Services

- Runs-on Request service
- Interactive On-Line Visualization of simulation results,
- Kameleon access and interpolation library,
- Space Weather Explorer (SWX -3D visualization tool),
- Integrated Space Weather Analysis System (ISWA).

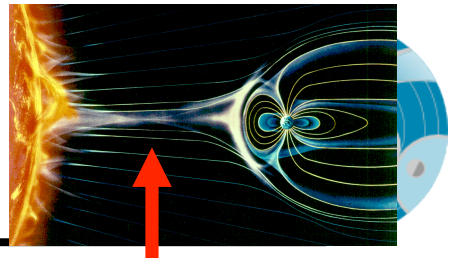
Heliophysics Laboratory Primer



- Heliosphere
- Magnetosphere
- Ring Current/Radiation Belt
- Ionosphere/Thermosphere

Please click **here** to launch/download the most current version of
Space Weather Explorer 2 (SWX2)

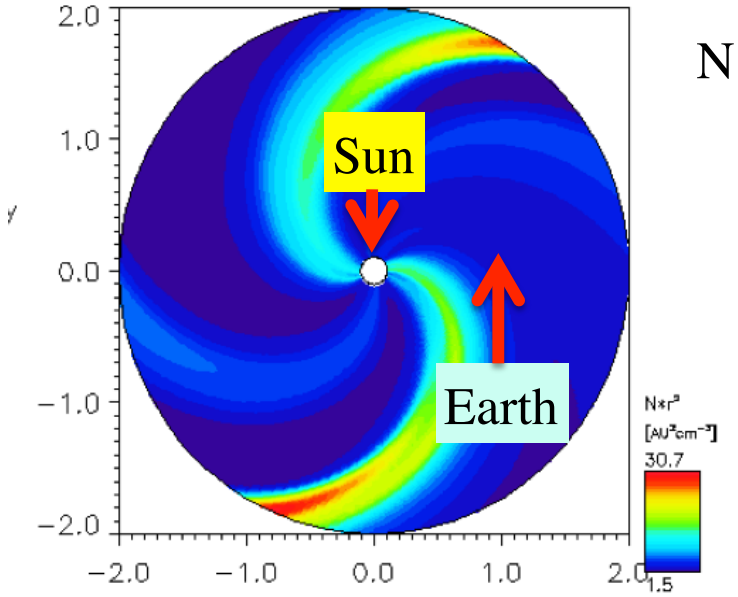
Heliospheric models



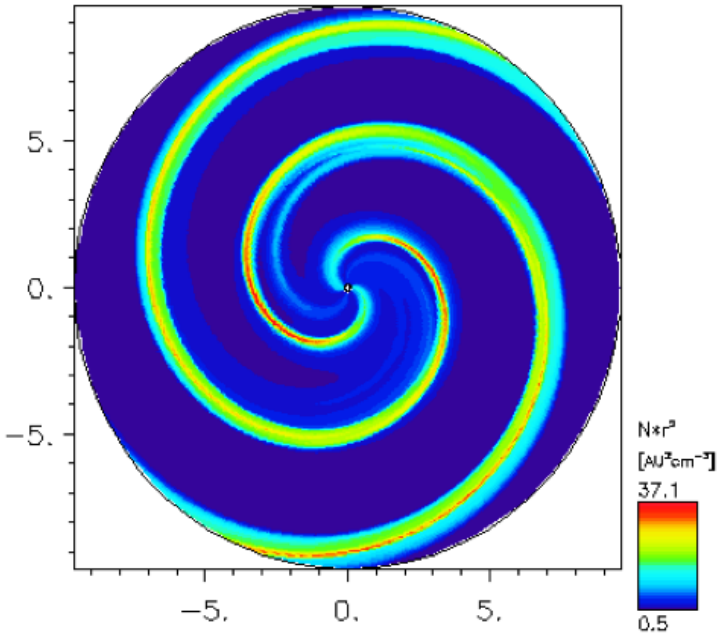
Complete, physics-based, heliosphere:

21.5 R_s – 2 AU

21.5 R_s – 10 AU



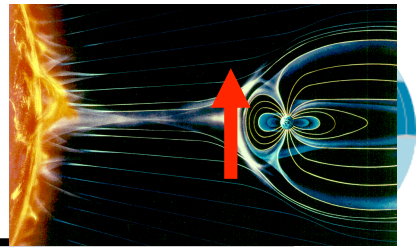
N R^2



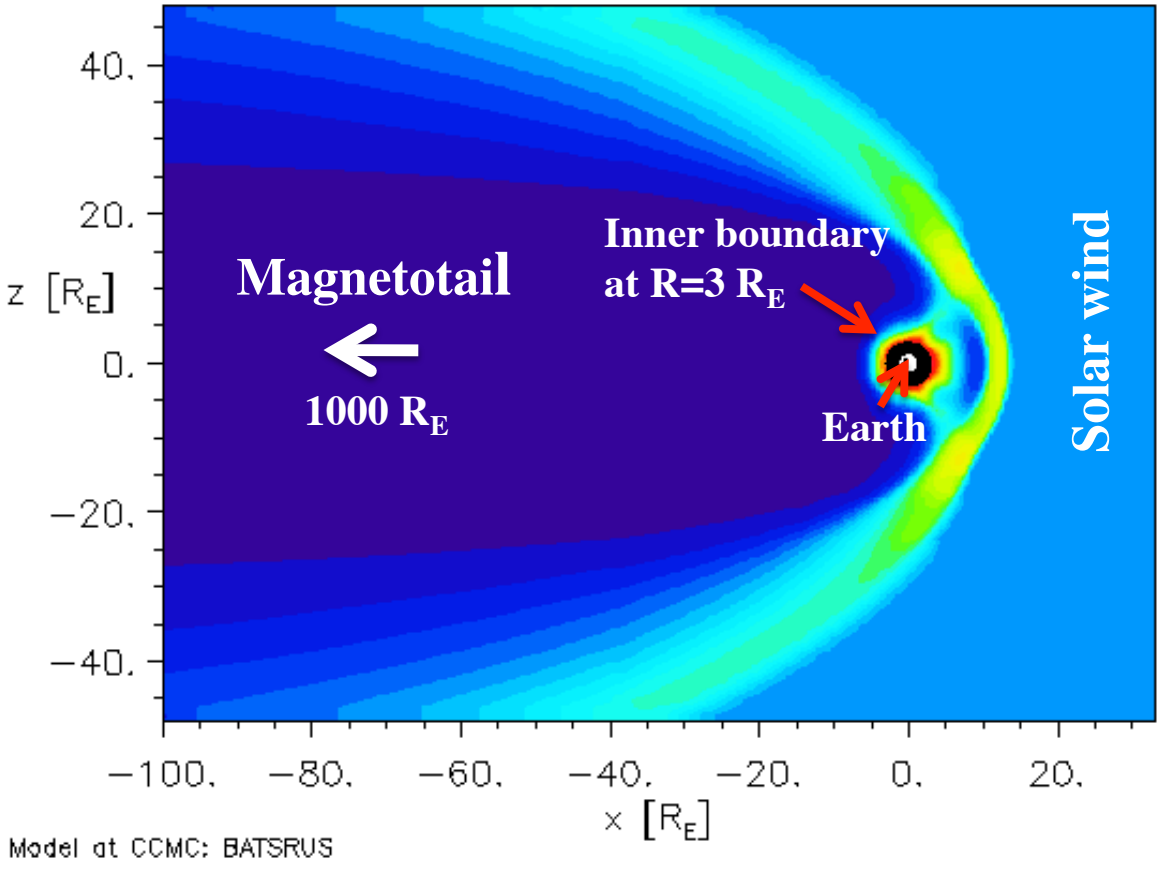
ENLIL (Odstrcil – NASA/GSFC)

SWMF/SH (Gombosi et al – Univ of Mich.)

Magnetospheric models

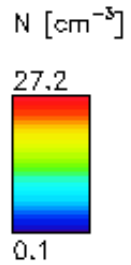


Global MHD Models: Gombosi et al), OpenGGCM (Raeder), LFM (Lyon et al)



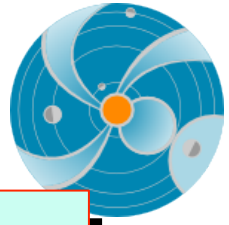
Sunward (inflow) boundary at X=33 R_E: Solar wind parameters are applied here propagated from SW monitor, ACE at ~ 200 R_E

Sun



Number density

On-line Visualization
Magnetosphere, Ring Current Electrons

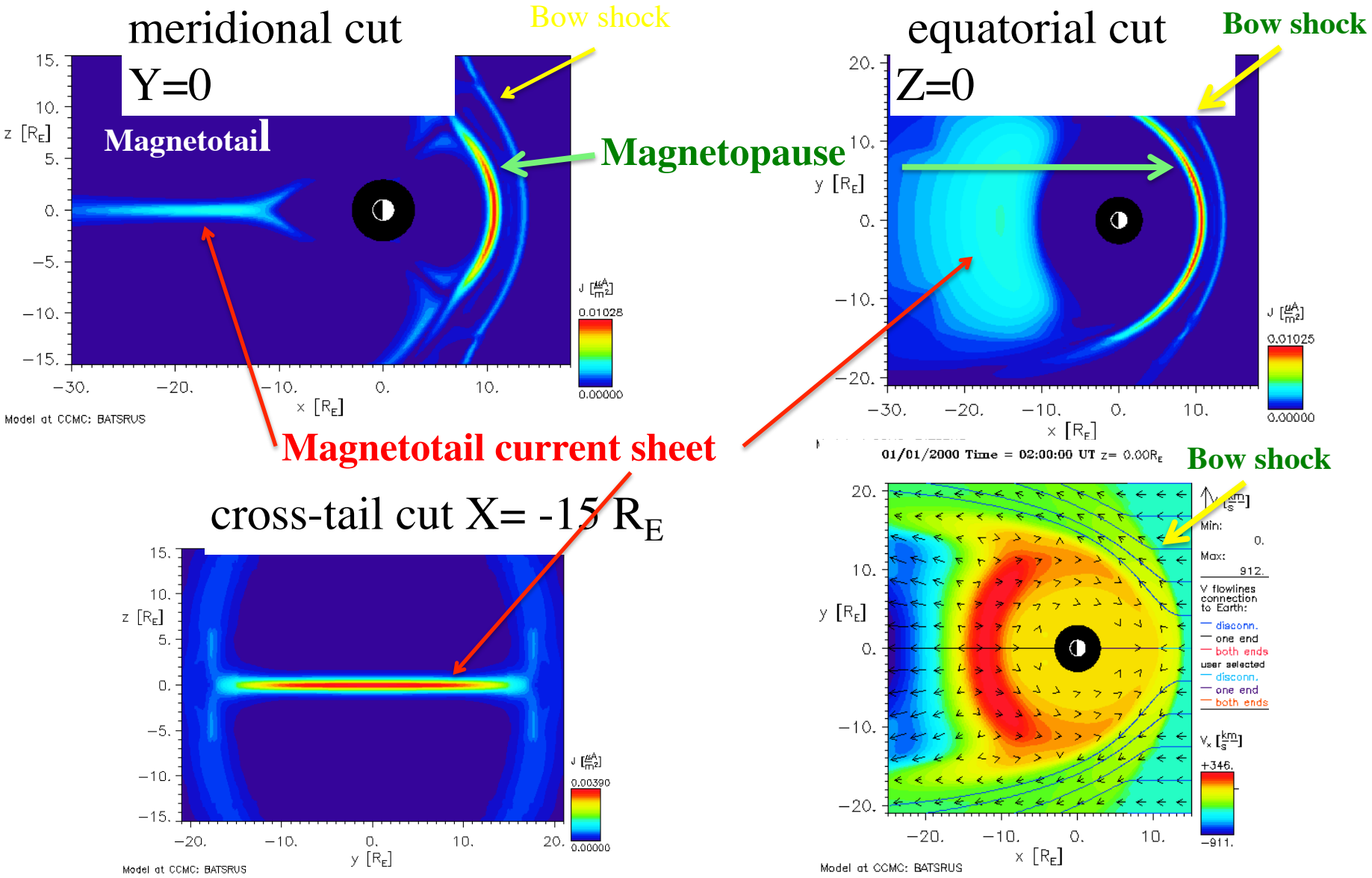


Click here

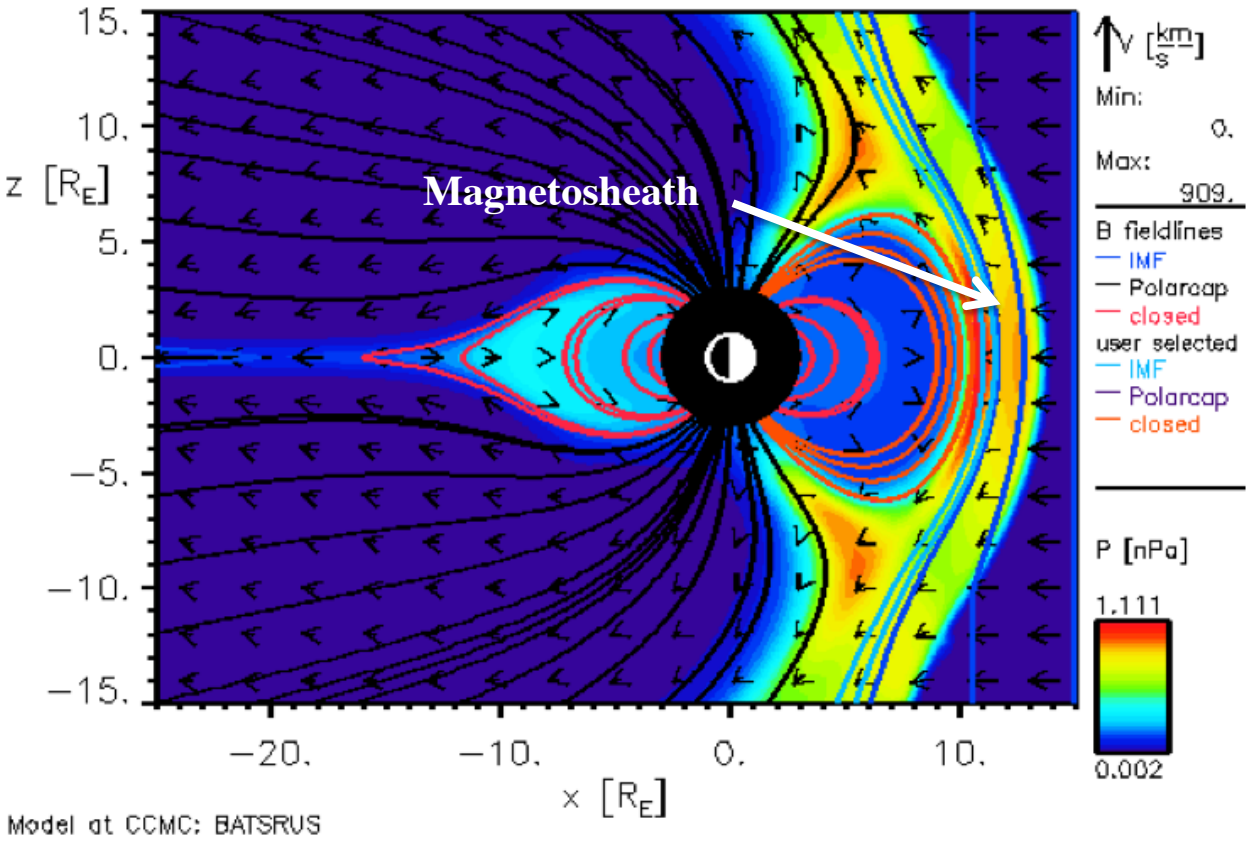
Results of magnetosphere, ring current (RC) and radiation belt (RB) simulations with artificial conditions

Run Number	Key Words	Model	Model Version	Start Time	End Time	Dipole Tilt (in the X-Z Plane) at Start deg	N	V_x	V_y	|B|	IMF Clock Angle
HSS2011_SWMF_053111_2	HSS2012, Southward IMF	BATSRUS	v8.01	2000/01/01 00:00	2000/01/01 02:00	0.00	5.00000	-400.00000	0.00000	5.00000	180.0
HSS2011_SWMF_053111_4	HSS2012, Northward IMF	BATSRUS	v8.01	2000/01/01 00:00	2000/01/01 02:00	0.00	5.00000	-400.00000	0.00000	5.00000	0.0
HSS2012_SWMF_052212_1	HSS2012, North-South IMF turning	SWMF	v20110131	2000/01/01 00:00	2000/01/01 05:00	0.00	5.00000	-400.00000	0.00000	5.00000	0

Magnetosphere in Different Cut Planes

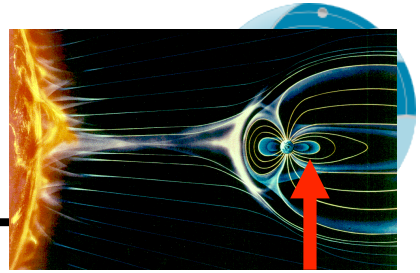


Magnetosphere: Magnetic Field Lines

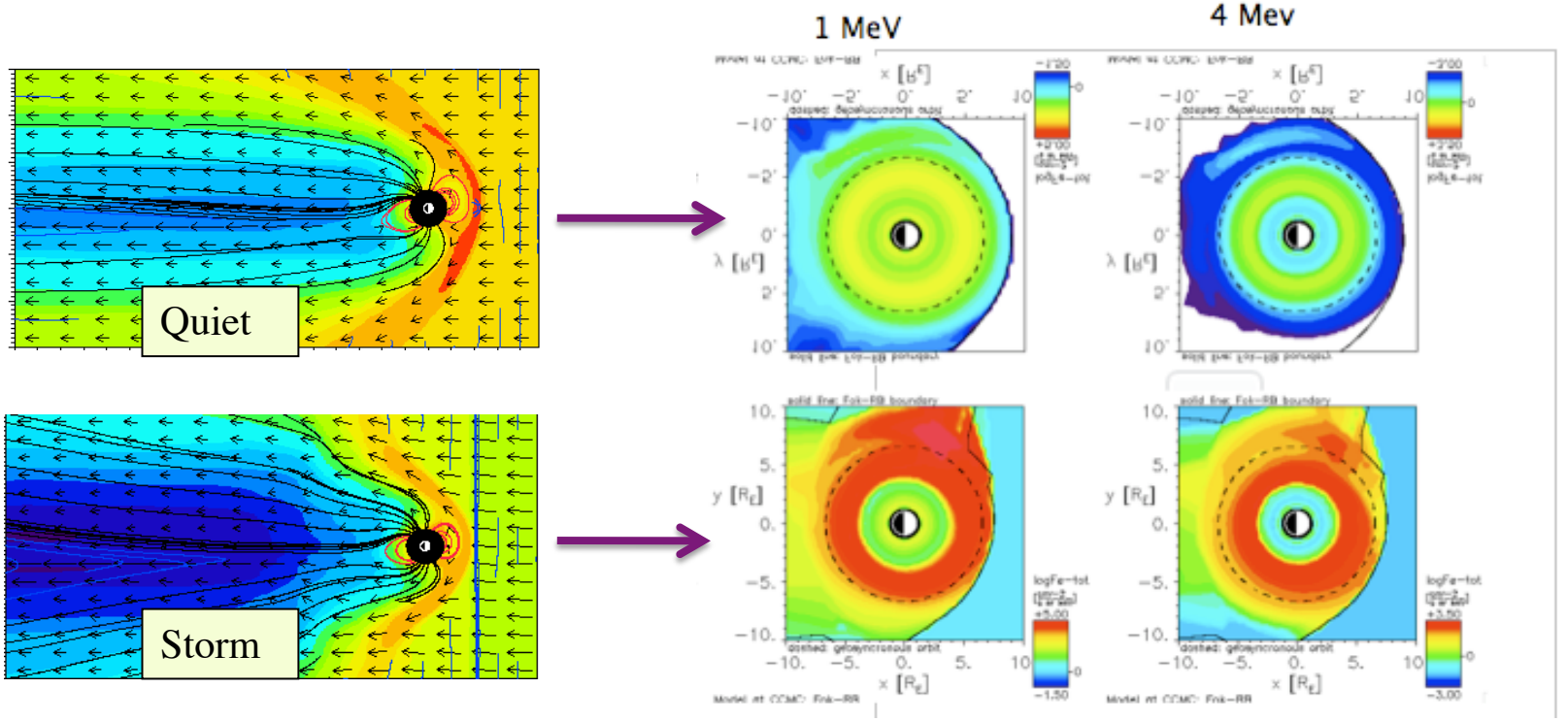


Red lines (closed): Magnetic field (MF) lines with both ends connected to the Earth
Black lines (open): MF lines with only one end a the Earth
Blue lines (interplanetary): MF lines with both ends in the interplanetary space

Inner magnetospheric models Include non-MHD physics



Ring Current and Radiation Belt Models (3 Models, GSFC and UMichigan) – high energy particle fluxes (~keV – MeV)



On-Line Visualization: Ring Current Electrons

HSS2012_SWMF_052212_1

Title/Introduction:

Key Word: HSS2012, North-South IMF turning

Model Type: GM
Model: SWMF version v20110131

- View solar wind input data
- List solar wind input data in ASCII format (see format description here).
- View Magnetosphere
- Create Timeseries in Magnetosphere
- View Ionosphere

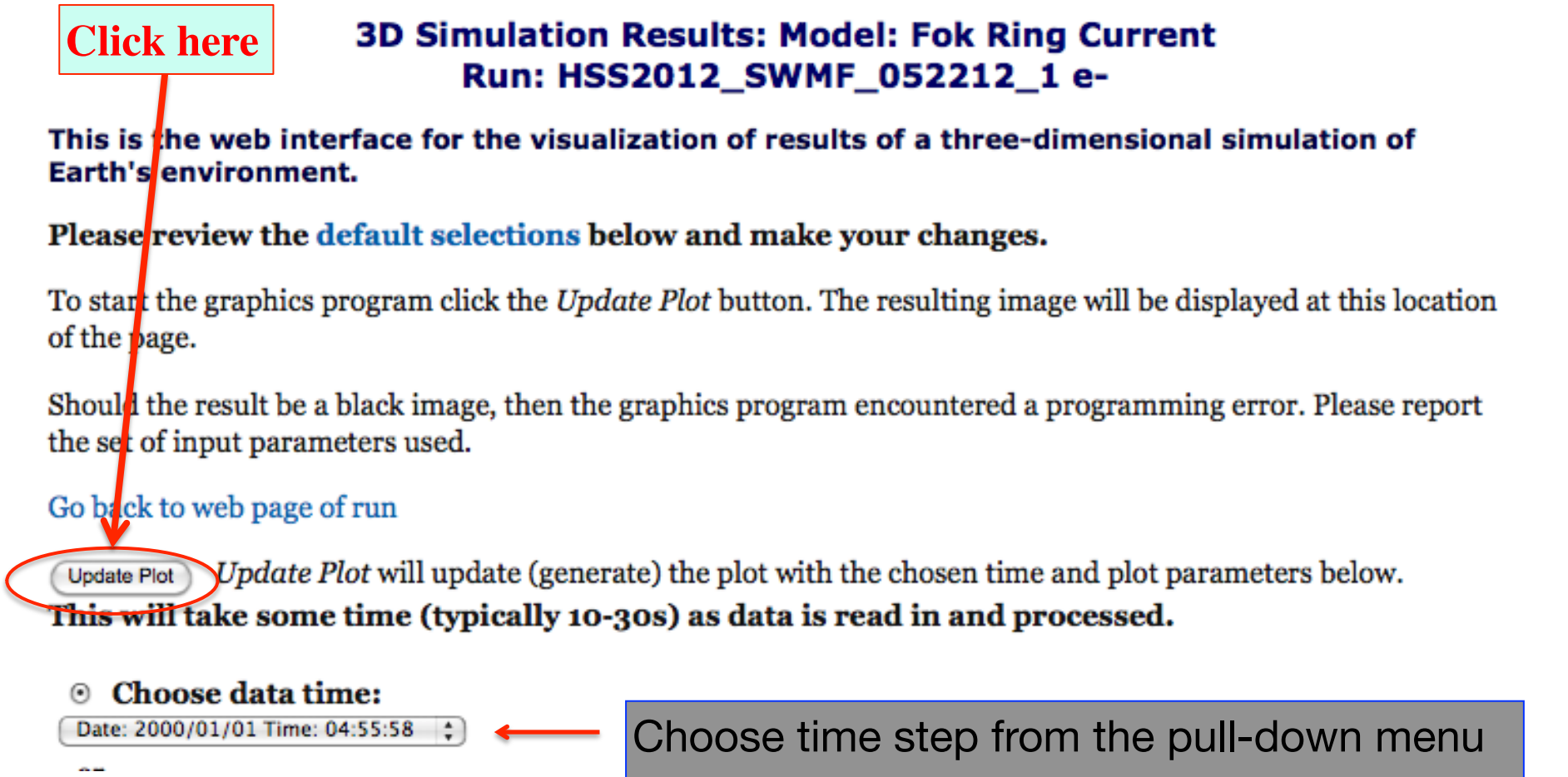
View pre-computed timeseries data:

- Northern hemisphere polar cap flux and area
- Southern hemisphere polar cap flux and area
- Magnetopause standoff and closest approach within 30 deg. of Sun-Earth line (local noon)
- Polar cap boundary at 24 magnetic local times
- Ionospheric dissipation

- View Fok Ring Current Electrons
- View Fok Ring Current Protons

Click here

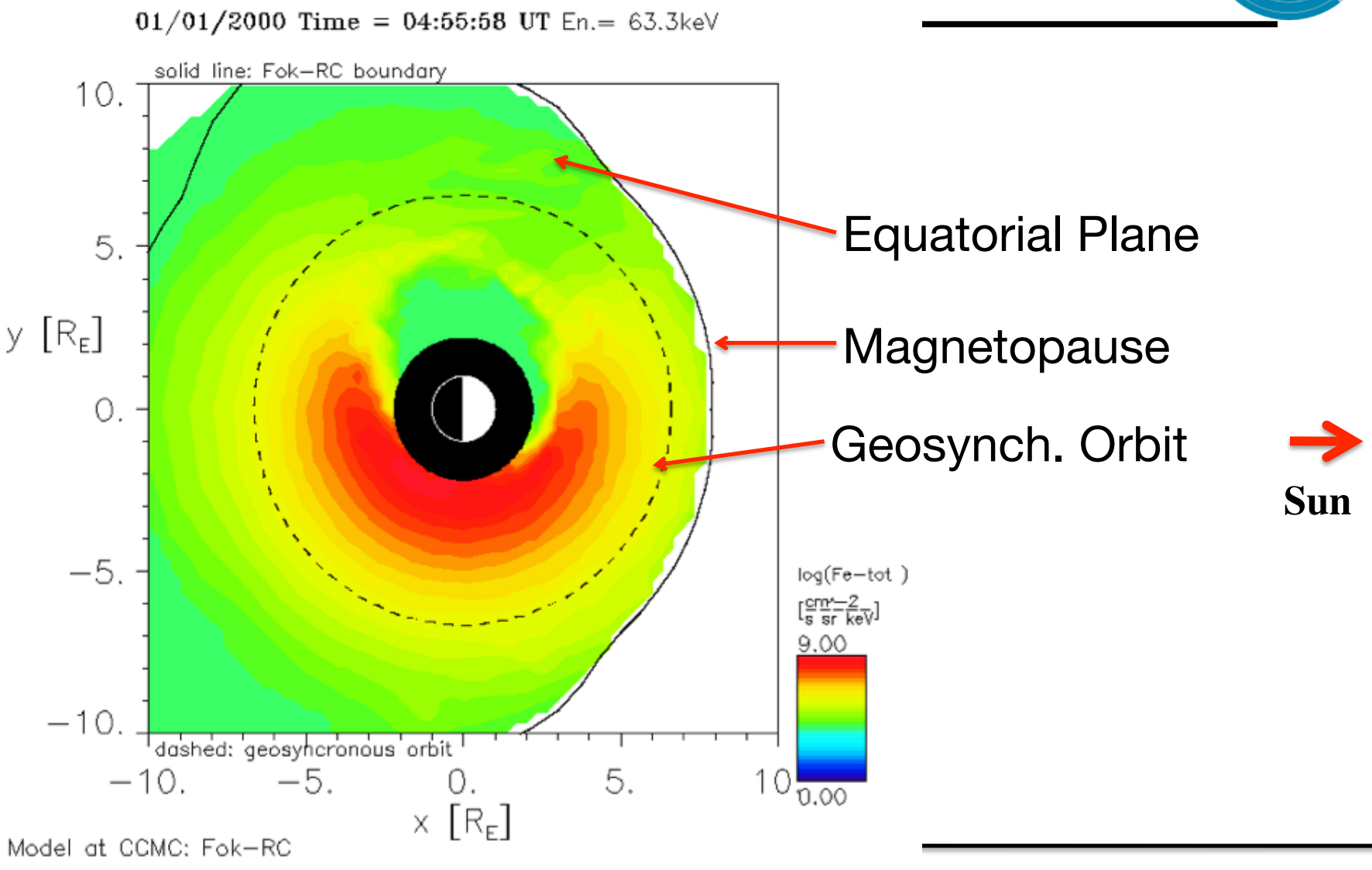
Make a First Plot with Default Selections



Choose time step from the pull-down menu

Click "**Update Plot**" to make a plot with default selections

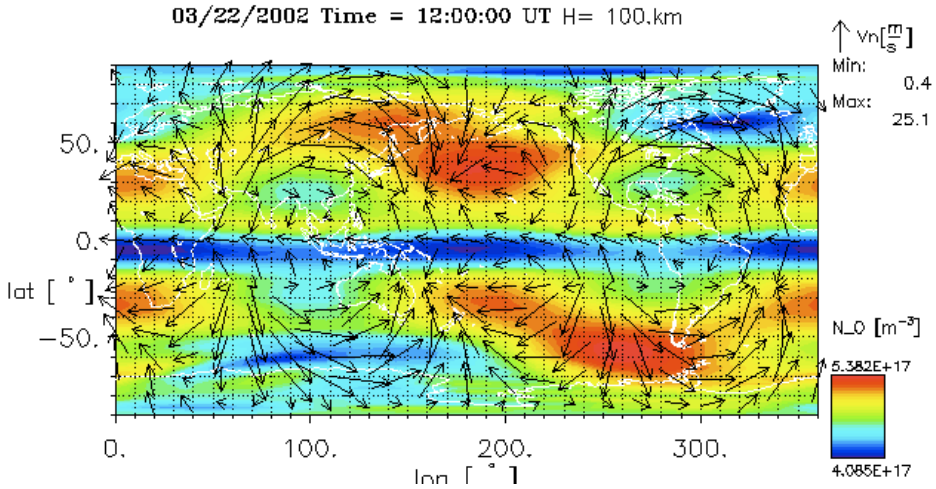
Electron Total Flux.
Energy 63.3 keV. Color Contour



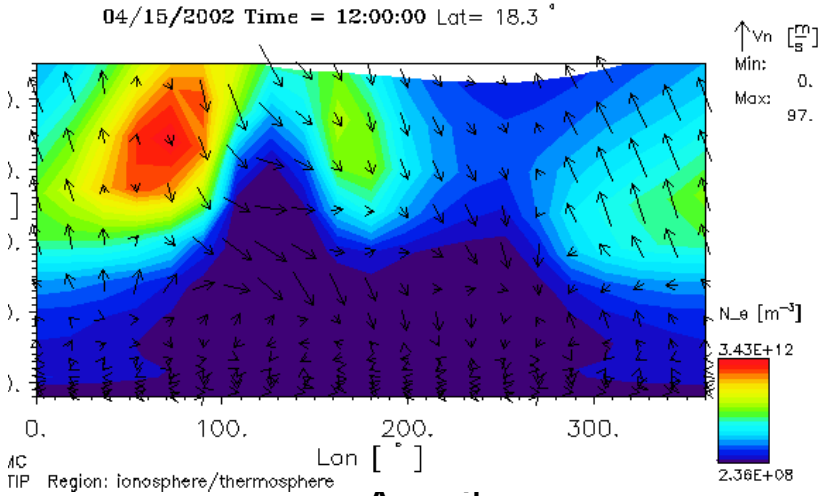
Earth radius

Coupled Ionosphere-Thermosphere Plasmasphere Model (CTIP) (Fuller-Rowell et al. NOAA, SWPC)

H = 100 km Slice
Colors: Oxygen Ions Density
Vectors: Neutral Velocity



Lat = 18.34 Slice
Colors: Electron Density

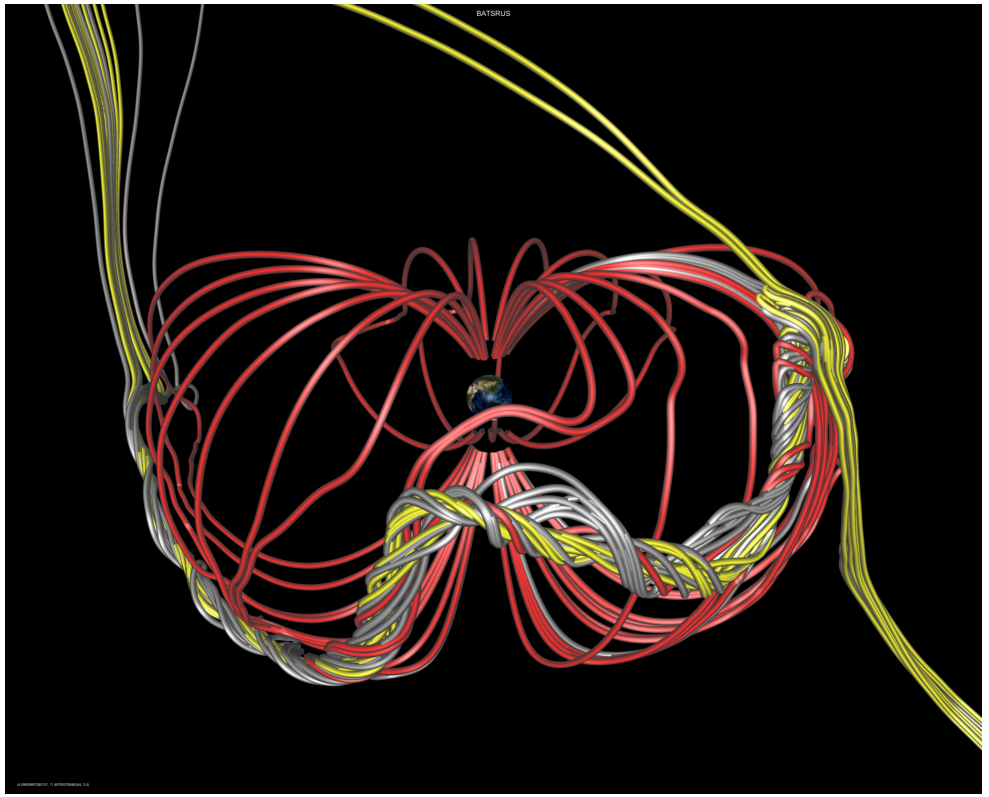


Arecibo
[18.34, 293.25]

Space Weather Explorer
http://ccmc.gsfc.nasa.gov/swx2

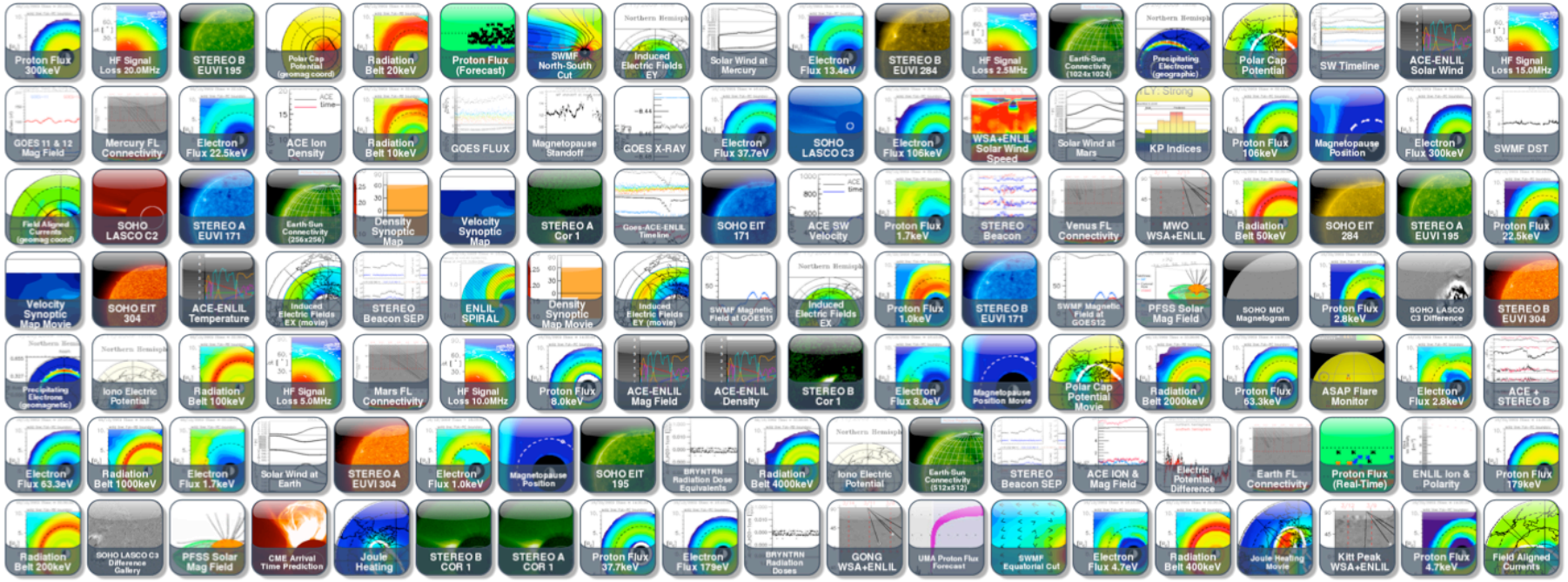
Features include:

- Java3D based
- 2D and 3D views
- User selectable cut planes
- Fast, flexible fieldline tracing
- Feature detection, includes open/closed field boundaries and critical points
- Interactive manipulation of the visualizations
- Exports 2D and 3D view in JPG, or PNG format

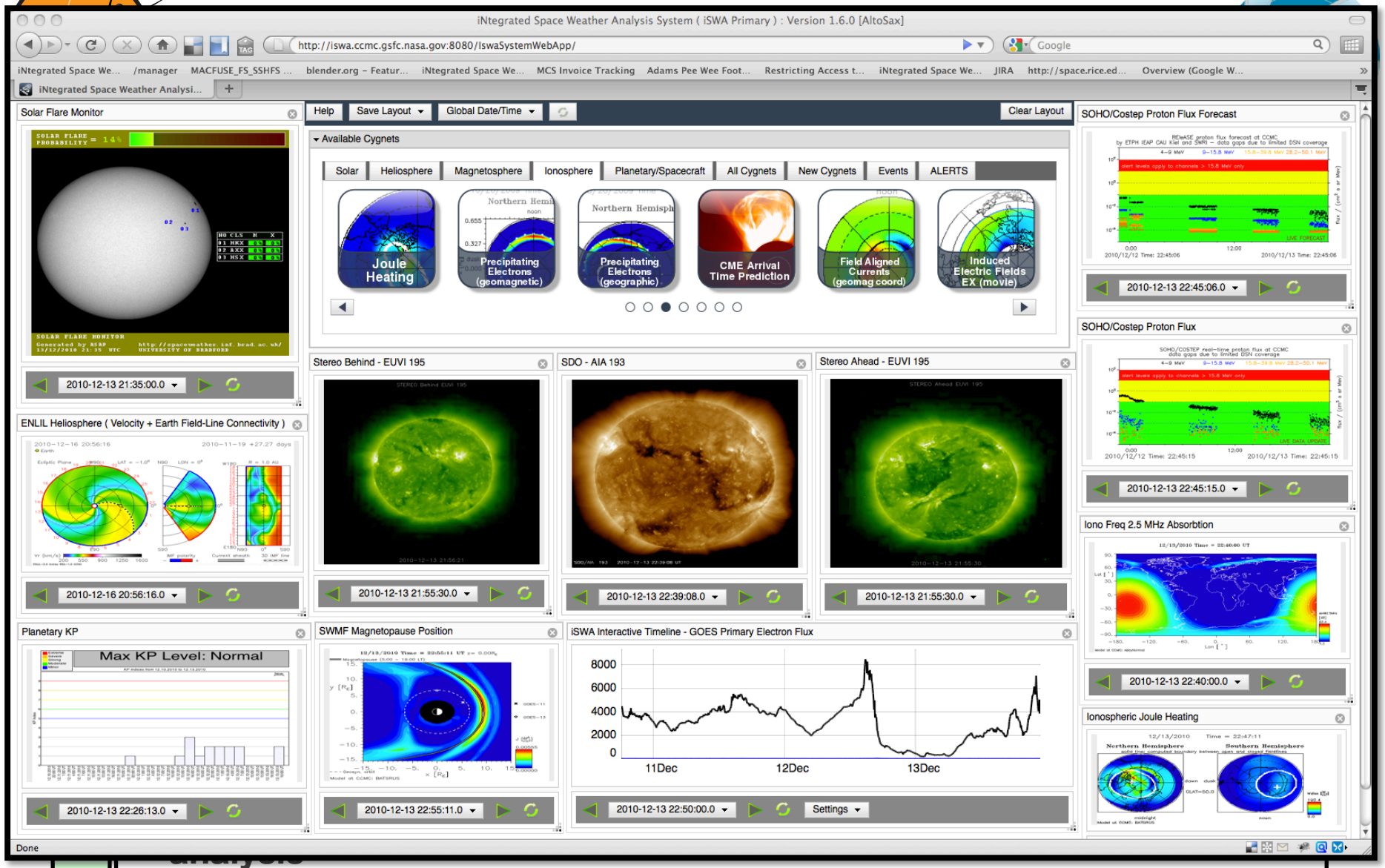


Innovative Dissemination: iSWA

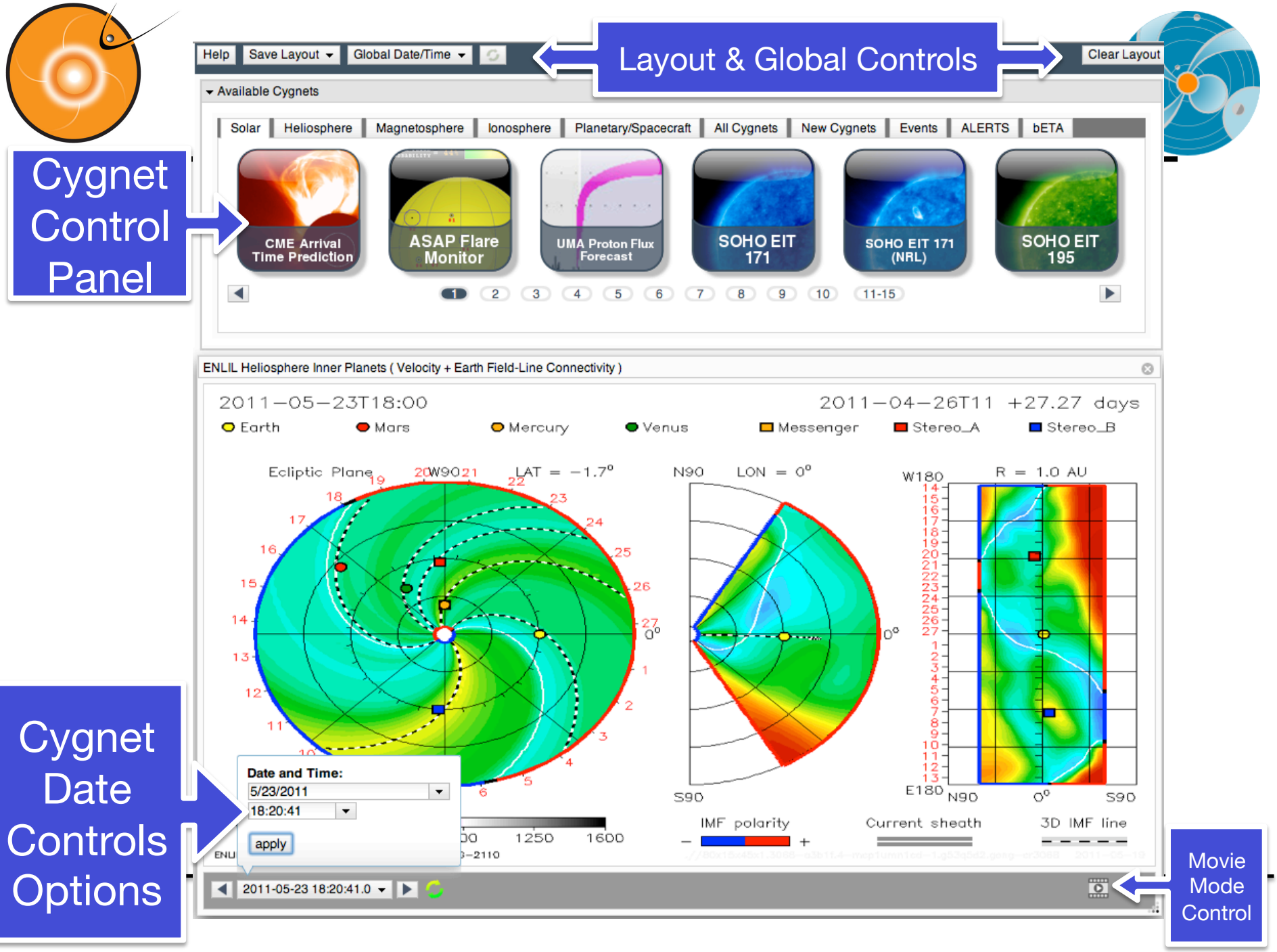
ISWA has ~300 products including modeling results and comprehensive sets of observational data.



Web-based. User configurable. Available world-wide.
One-stop shop for state-of-the-art information!
http://iswa.gsfc.nasa.gov

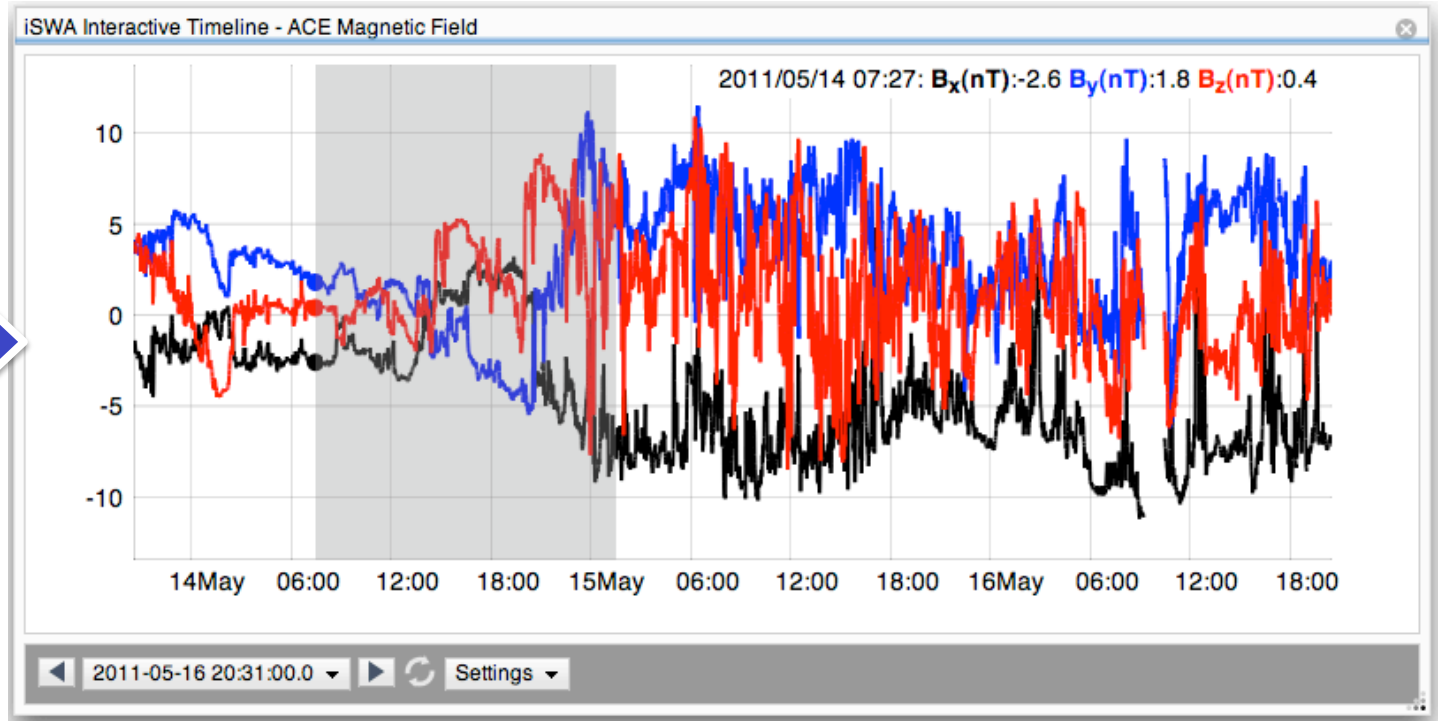


http://iSWA.ccmc.gsfc.nasa.gov


Layout & Global Controls
Cygnet Control Panel
Cygnet Date Controls Options
Movie Mode Control
Help
Save Layout
Global Date/Time
Clear Layout
Available Cygnets
Solar
Heliosphere
Magnetosphere
Ionosphere
Planetary/Spacecraft
All Cygnets
New Cygnets
Events
ALERTS
bETA
CME Arrival Time Prediction
ASAP Flare Monitor
UMA Proton Flux Forecast
SOHO EIT 171
SOHO EIT 171 (NRL)
SOHO EIT 195
1 2 3 4 5 6 7 8 9 10 11-15
ENLIL Heliosphere Inner Planets (Velocity + Earth Field-Line Connectivity)
2011-05-23T18:00
2011-04-26T11 +27.27 days
Earth
Mars
Mercury
Venus
Messenger
Stereo_A
Stereo_B
Ecliptic Plane
LAT = −1.7°
N90
LON = 0°
S90
W180
R = 1.0 AU
E180
IMF polarity
Current sheath
3D IMF line
Date and Time:
5/23/2011
18:20:41
apply
1250
1600
2011-05-23 18:20:41.0

Interactive Products

Interactive timeline tool with pan, zoom, mouse-over, and quantity toggling functionality



iSWA Layouts

DEMO

iSWA layouts for recent significant SWx events

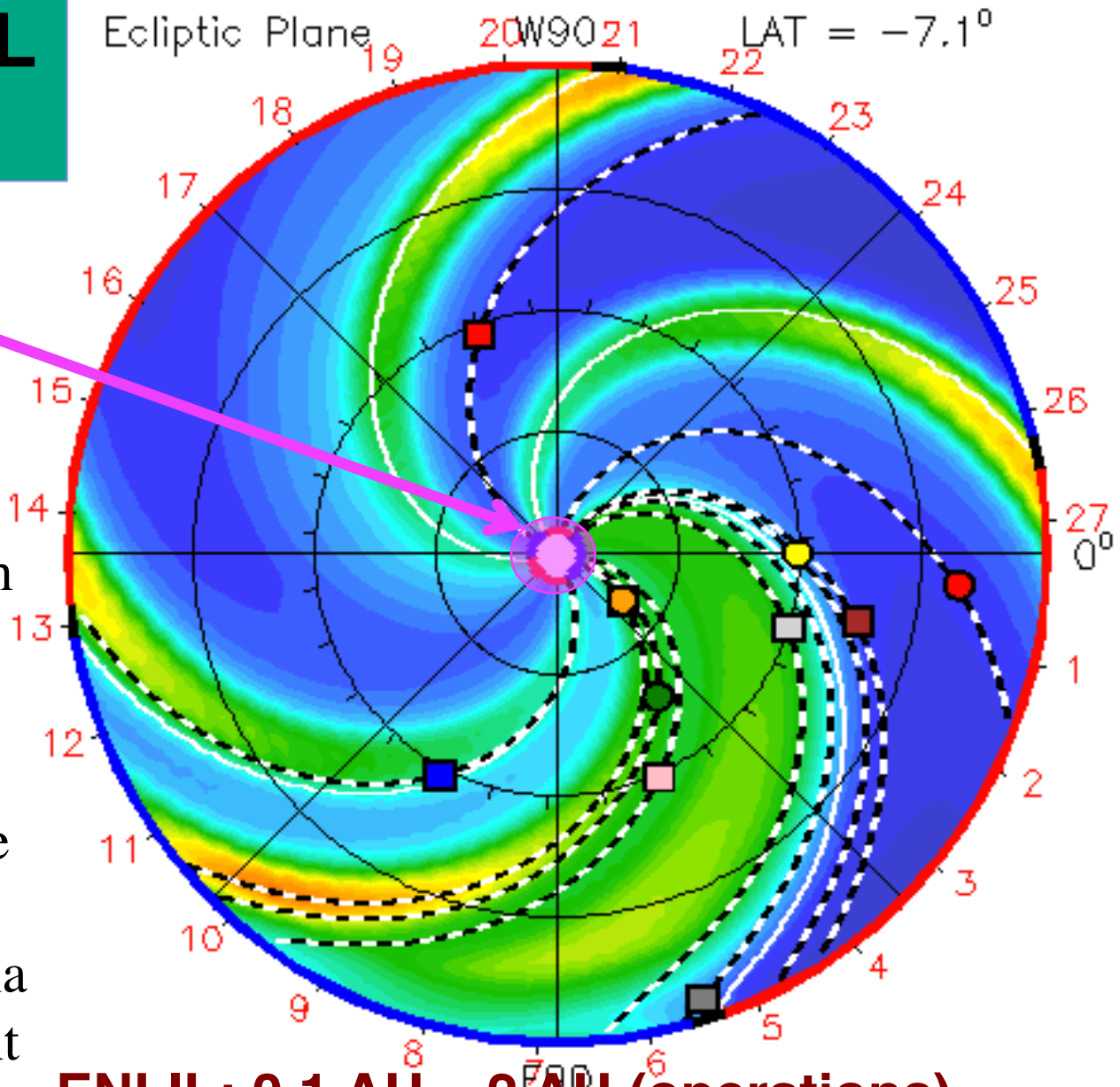
About WSA+ENLIL

The WSA+ENLIL Model Suite

Wang-Sheeley-Arge (WSA Model)

1 Rs – 21.5Rs (0.0046 -0.1AU)

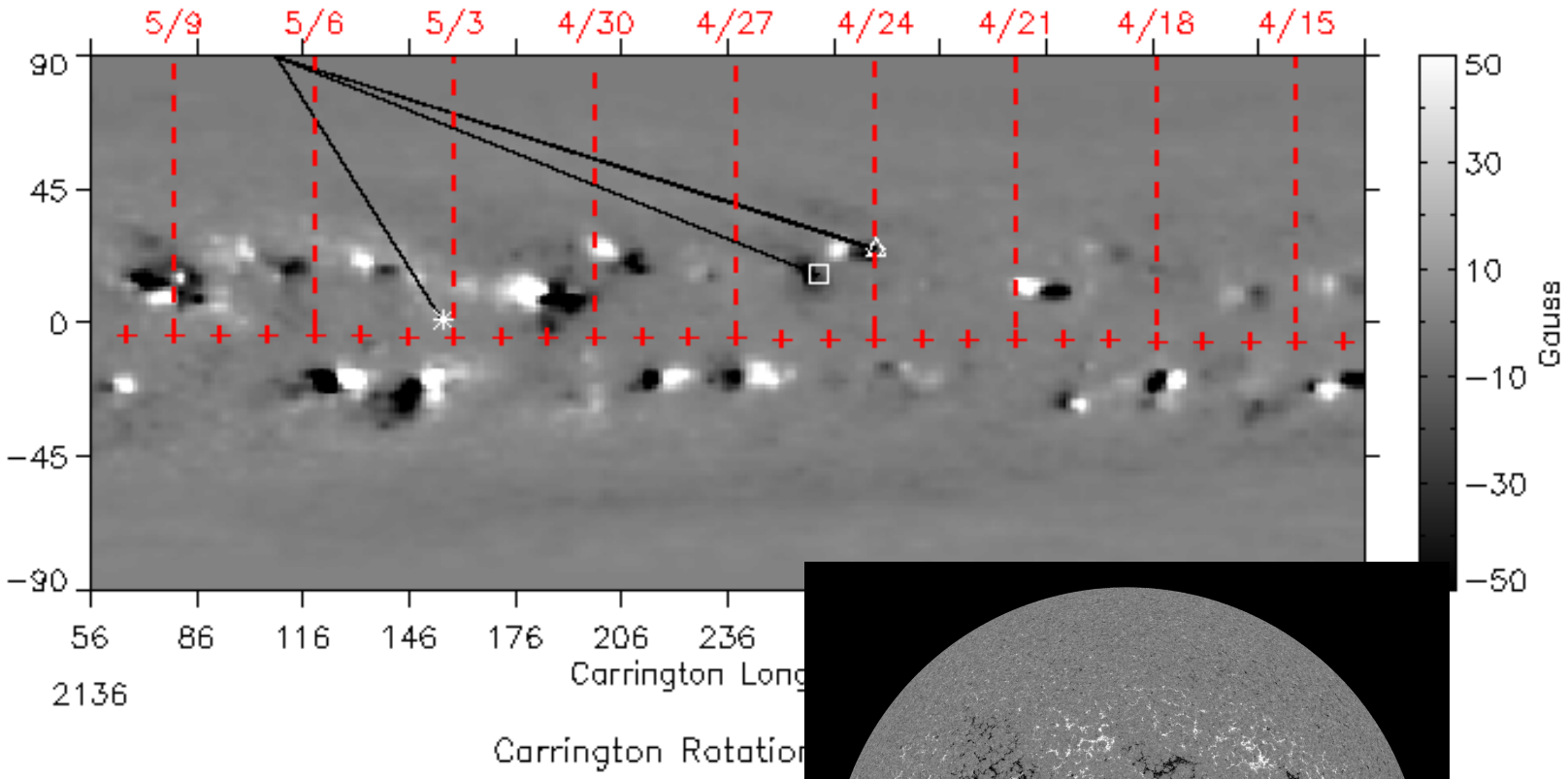
Photospheric magnetic field maps (can be from satellite observations such as SOHO/MDI or SDO/ HMI or ground-based observations such as the GONG magnetogram) are used as input to the WSA model (model solar corona up to 21.5 Rs) to represent the ambient solar wind.

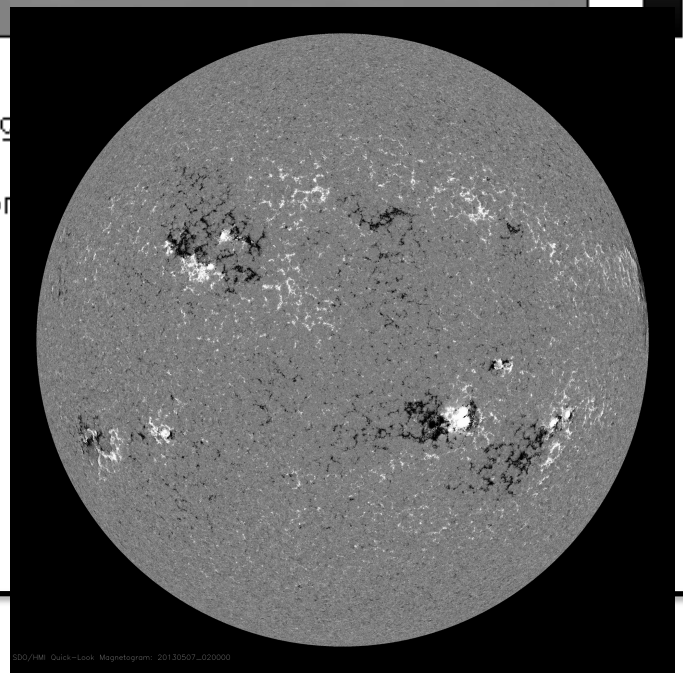


Model of the solar wind in the heliosphere

venus diamond
mercury square

Observed Photospheric Field from GON





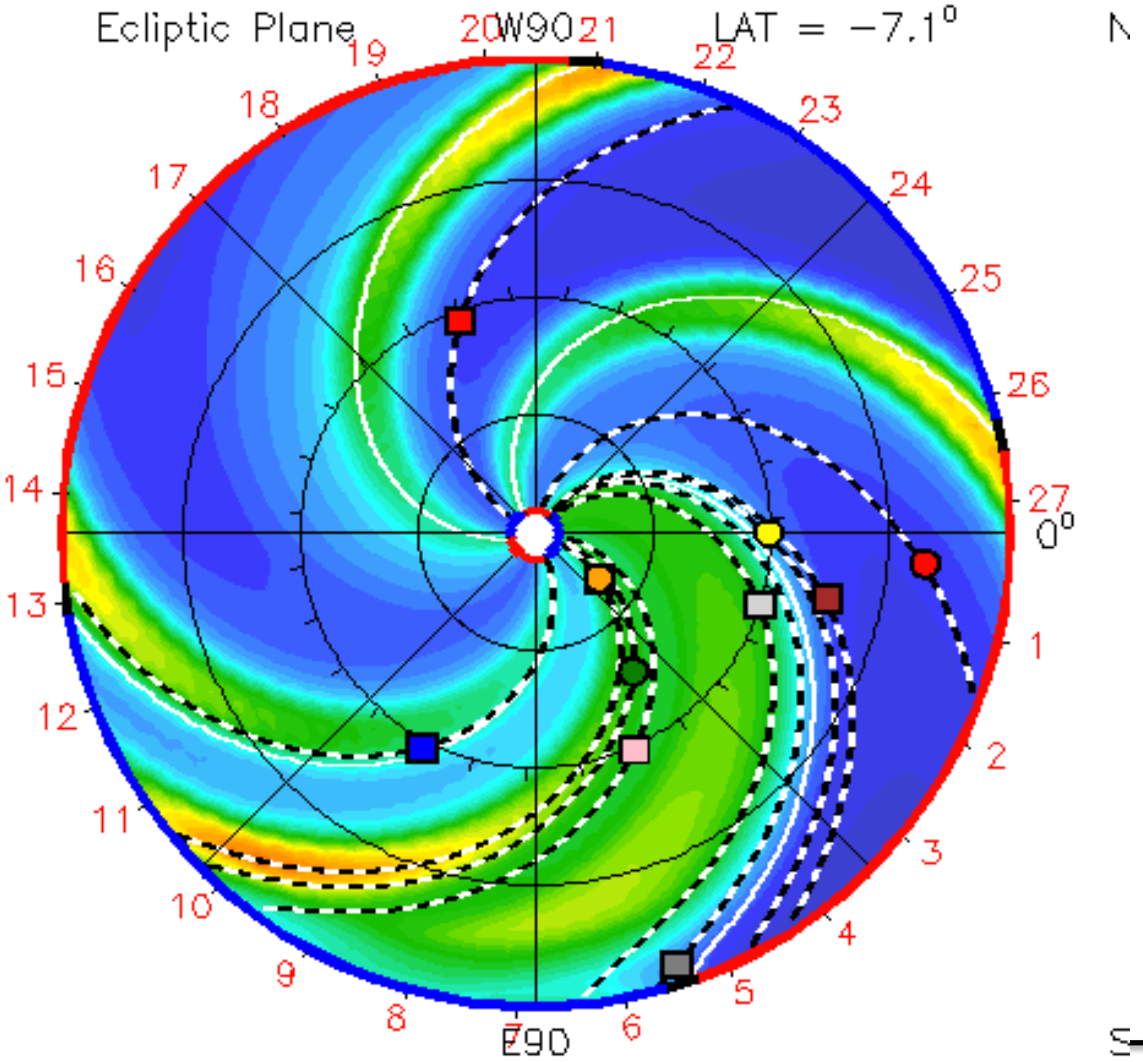
EN = Lord + LÍL = Storm, "Lord (of the) Storm"

wikipedia

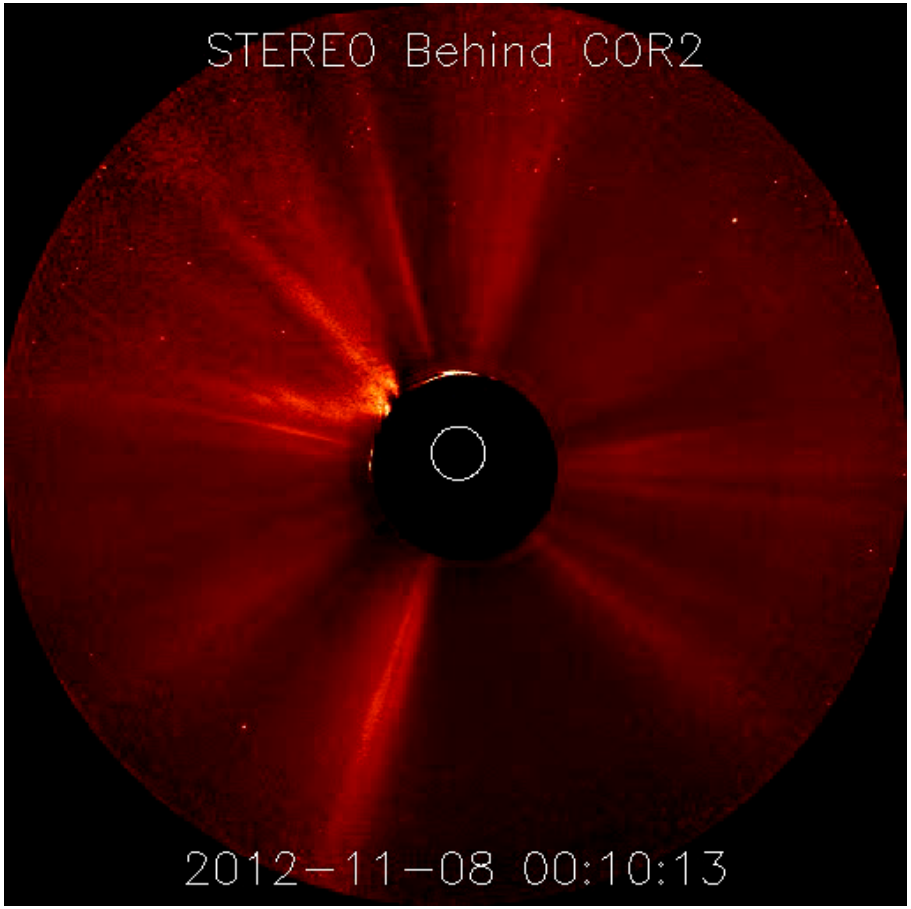
Courtesy: Dusan Odstrcil

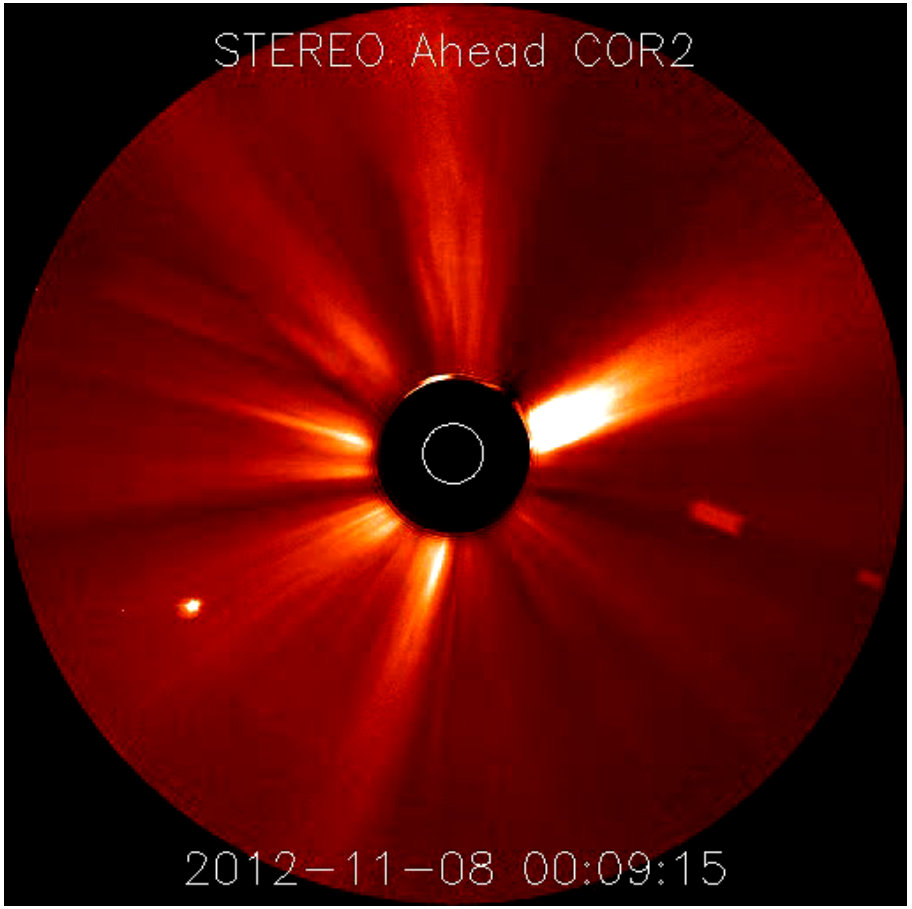
WSA+ENLIL:
capable of modeling the solar wind for both ‘fair’ weather and ‘storm’ conditions

Fair weather: ambient solar wind

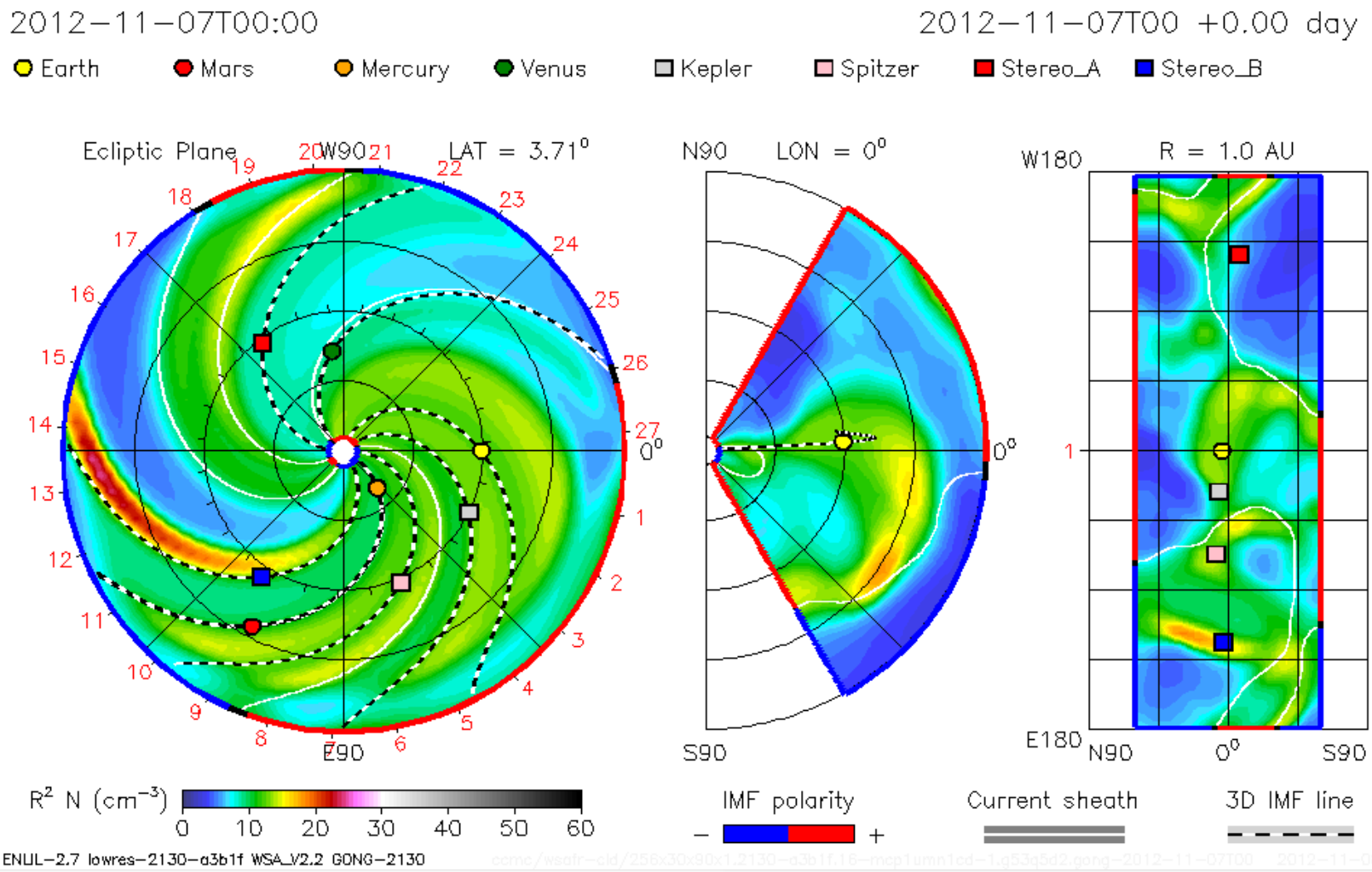


Stormy Weather: Eruptions (CME)

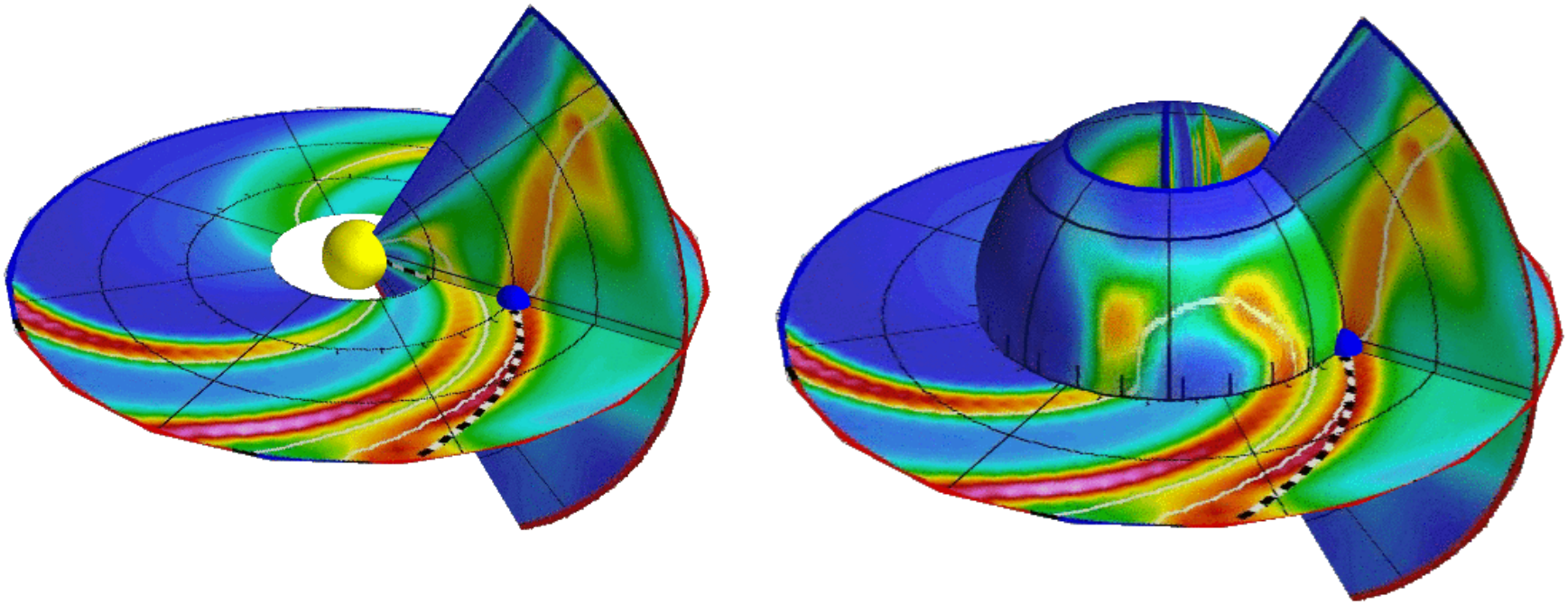




Modeling of solar wind under stormy conditions

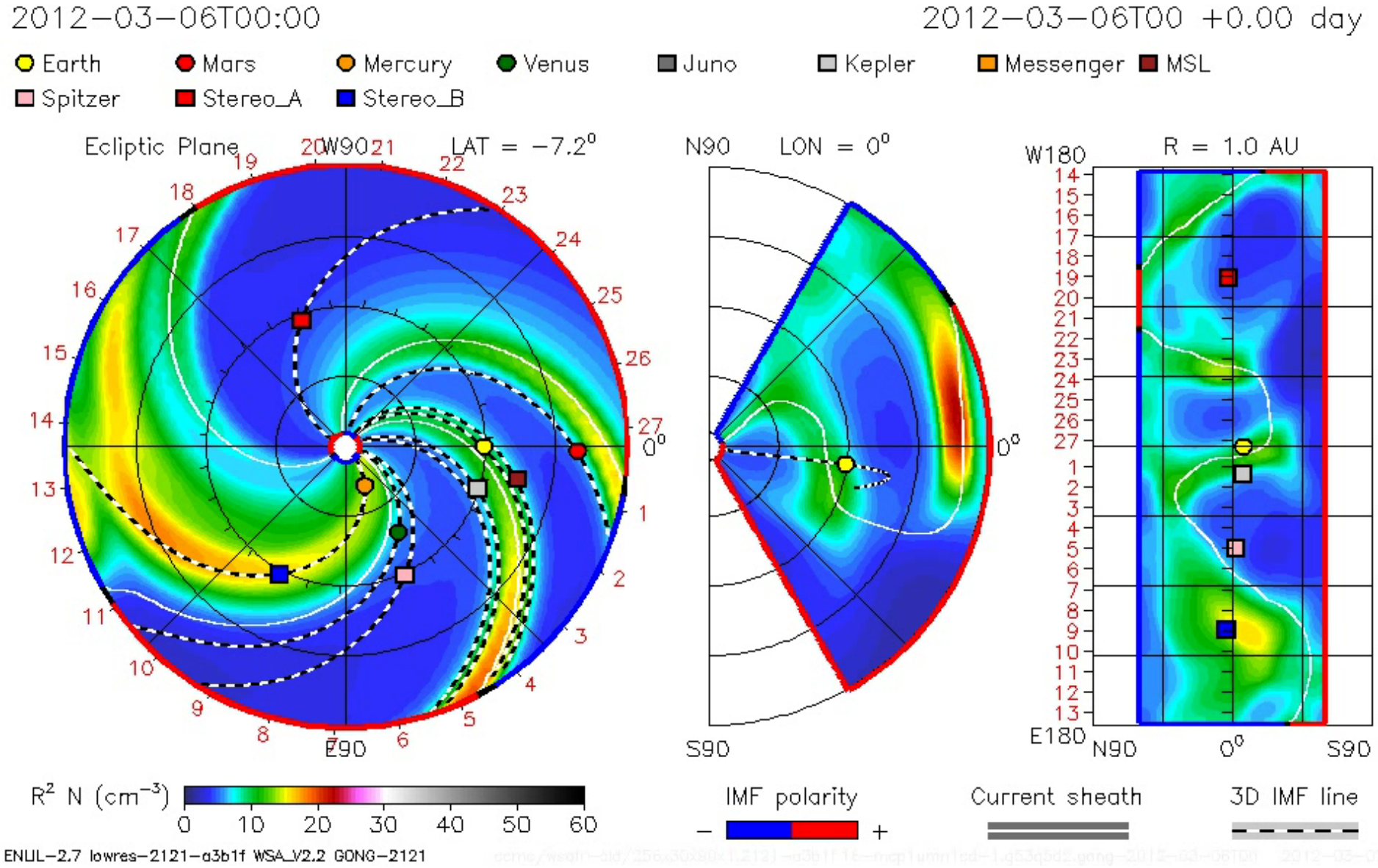


ENLIL Visualization

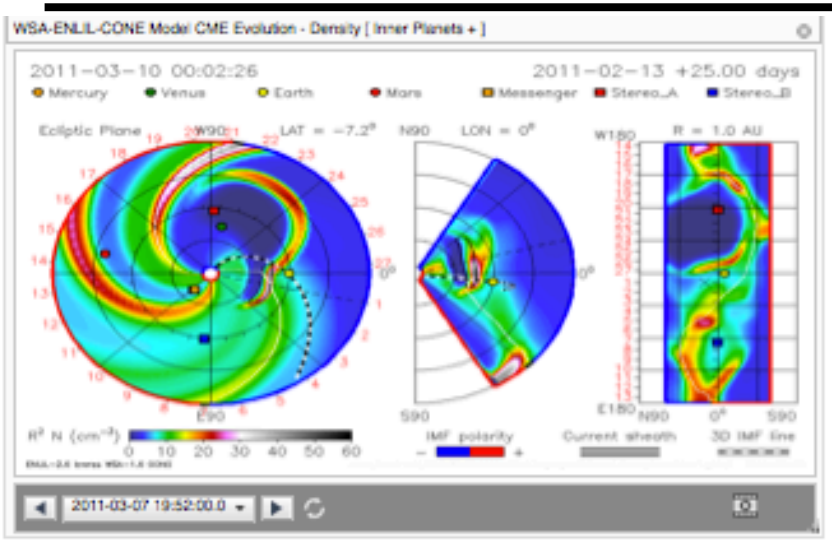


Courtesy of Stijn Calders @BIRA

Modeling of solar wind under stormy conditions
Earth-directed

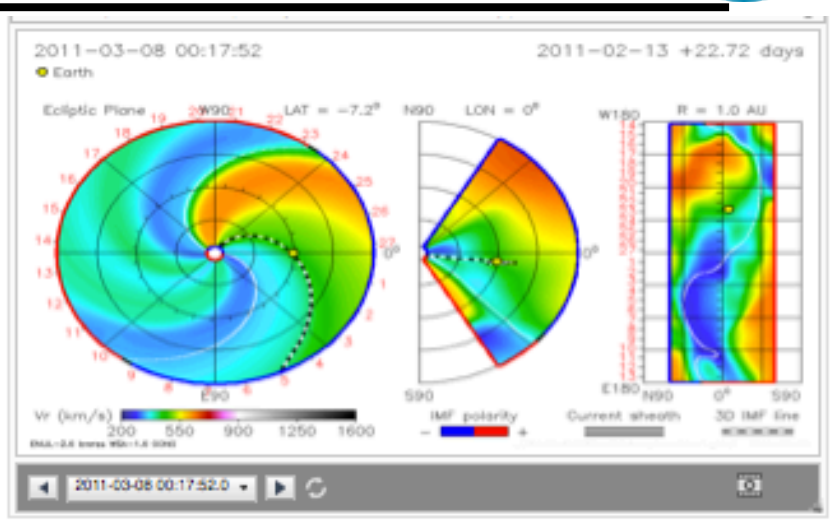


Forecasting capability enabled by WSA+ENLIL



WSA+ENLIL+cone

Predicting impacts of CMEs



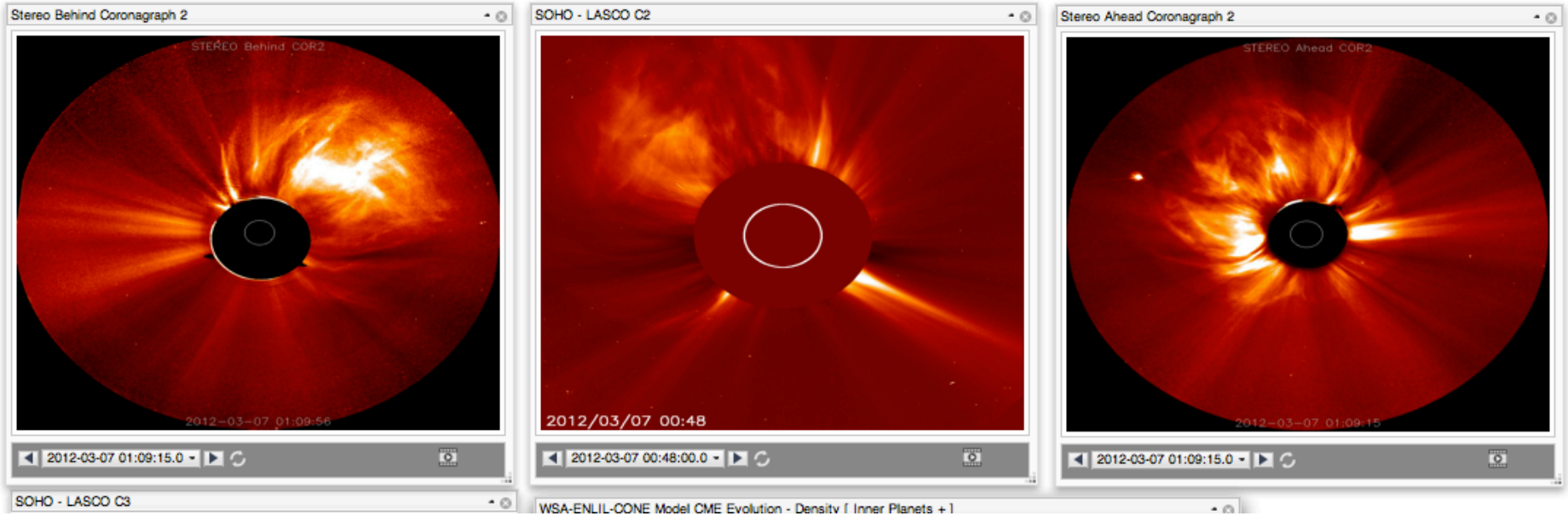
WSA+ENLIL

Modeling and predicting the ambient solar wind

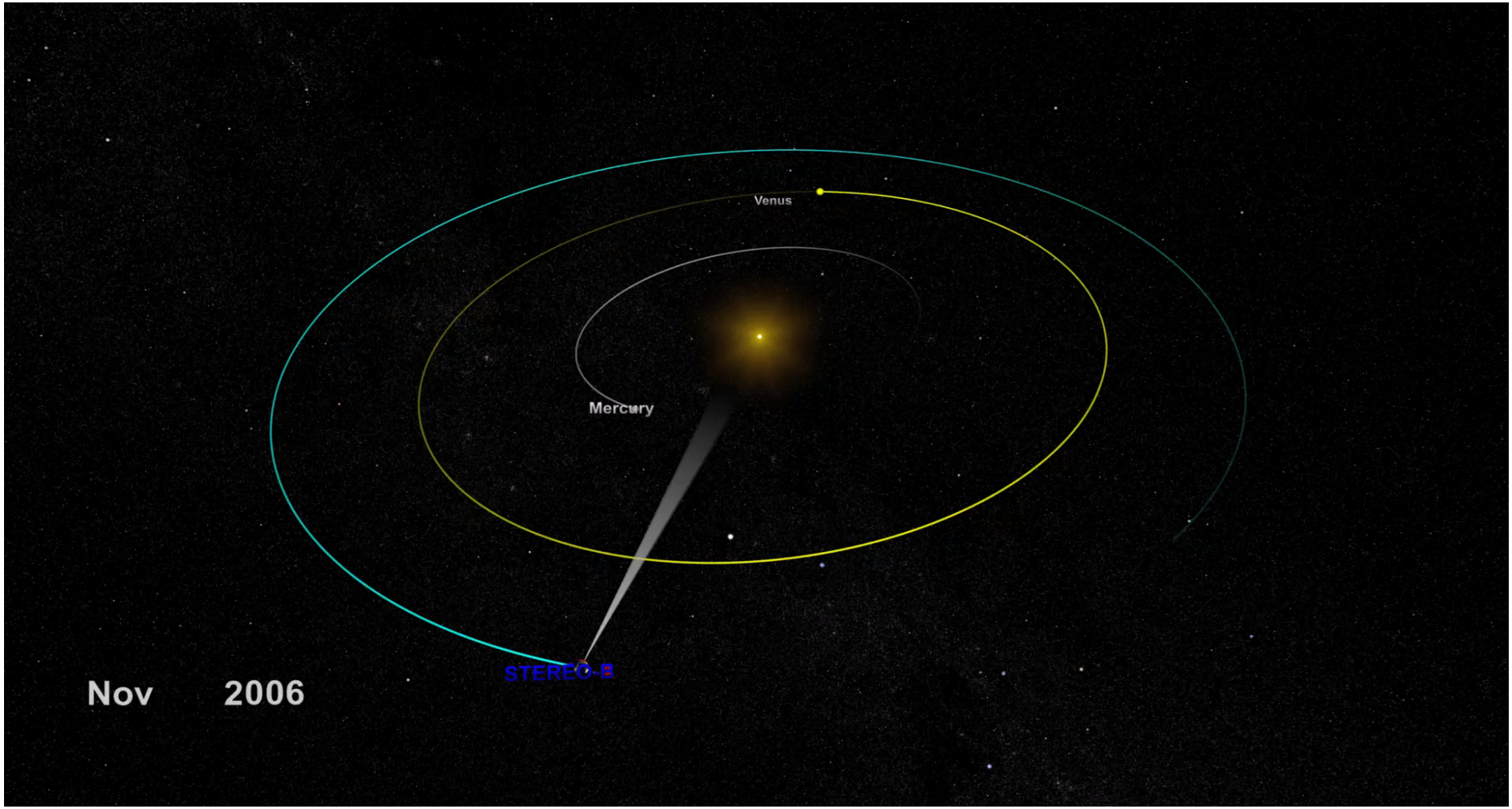
How to Model CMEs

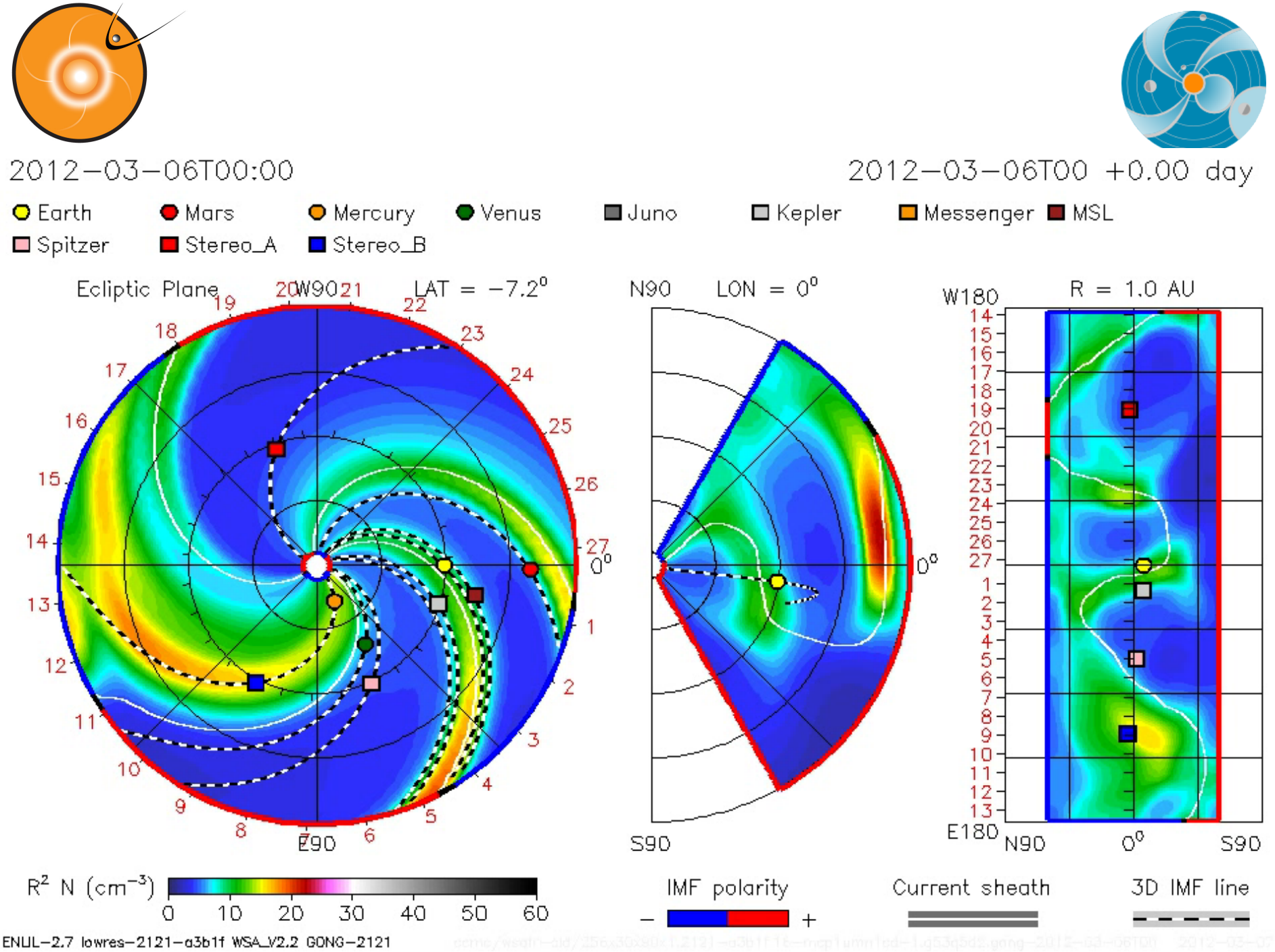
- Cone Concept

Stormy Weather: Occurrence of CMEs

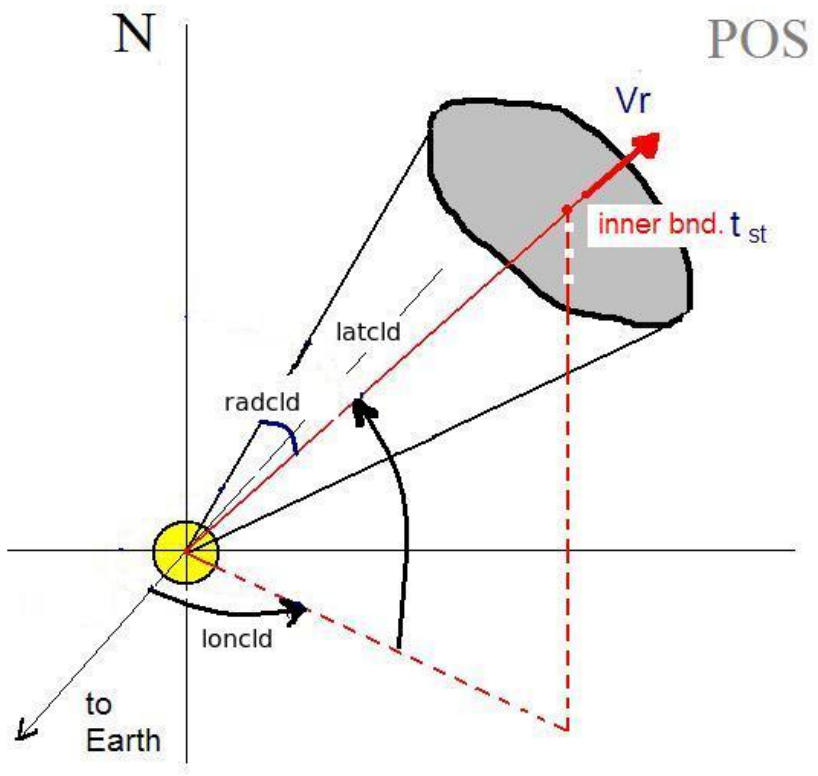


Orbits of STEREO A and B




2012-03-06T00:00
2012-03-06T00 +0.00 day
Earth
Mars
Mercury
Venus
Juno
Kepler
Messenger
MSL
Spitzer
Stereo_A
Stereo_B
Ecliptic Plane
LAT = −7.2°
W90
E90
N90
S90
LON = 0°
R = 1.0 AU
W180
E180
0°
R² N (cm⁻³)
0
10
20
30
40
50
60
IMF polarity
Current sheath
3D IMF line
ENLIL-2.7 lowres-2121-a3b1f WSA_V2.2 GONG-2121

Cone model parameters



- tstart - when cloud at 21.5Rs
- Latitude
- Longitude
- Radius (angular width)
- Vr - radial velocity

Input to ENLIL cone model run

Triangulation Tool

DEMO

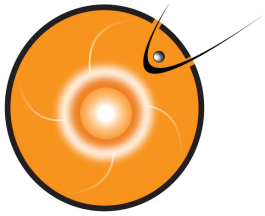
Start time of the event:
2013-04-11T07:36Z.
t1: 08:00Z
t2: 10:30Z

Triangulation Tool

DEMO of save function

Triangulation Tool

CME analysis tool - Antti



One Click for launching a CME simulation

CME Forecasting Score Board

Space Weather
Score Board

Score Board

Community ‘Ensemble’ Forecasting

Database Of Notifications, Knowledge, Information (DONKI)

Space Weather
D.O.N.K.I

(available soon)

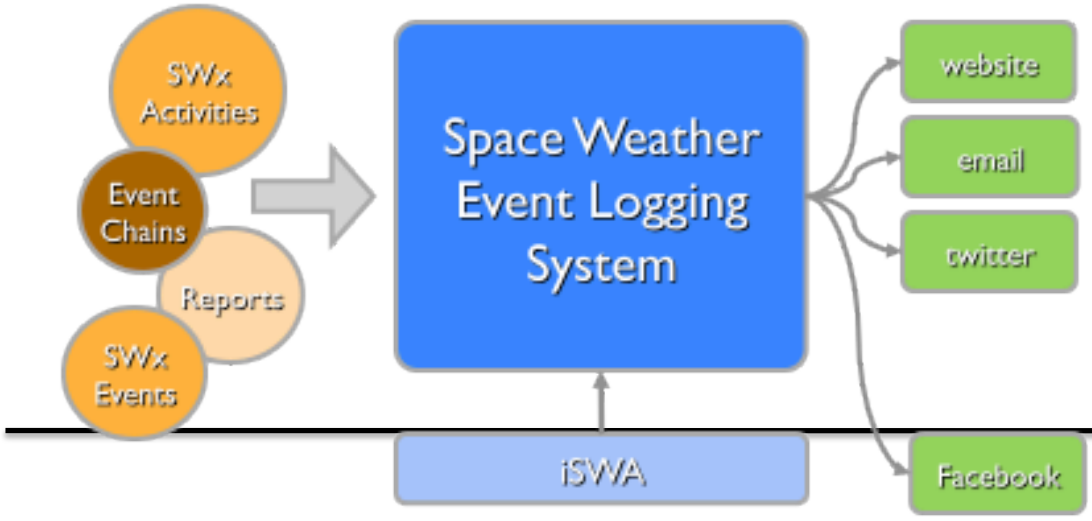
Based on forecasters daily logs and interns' research projects

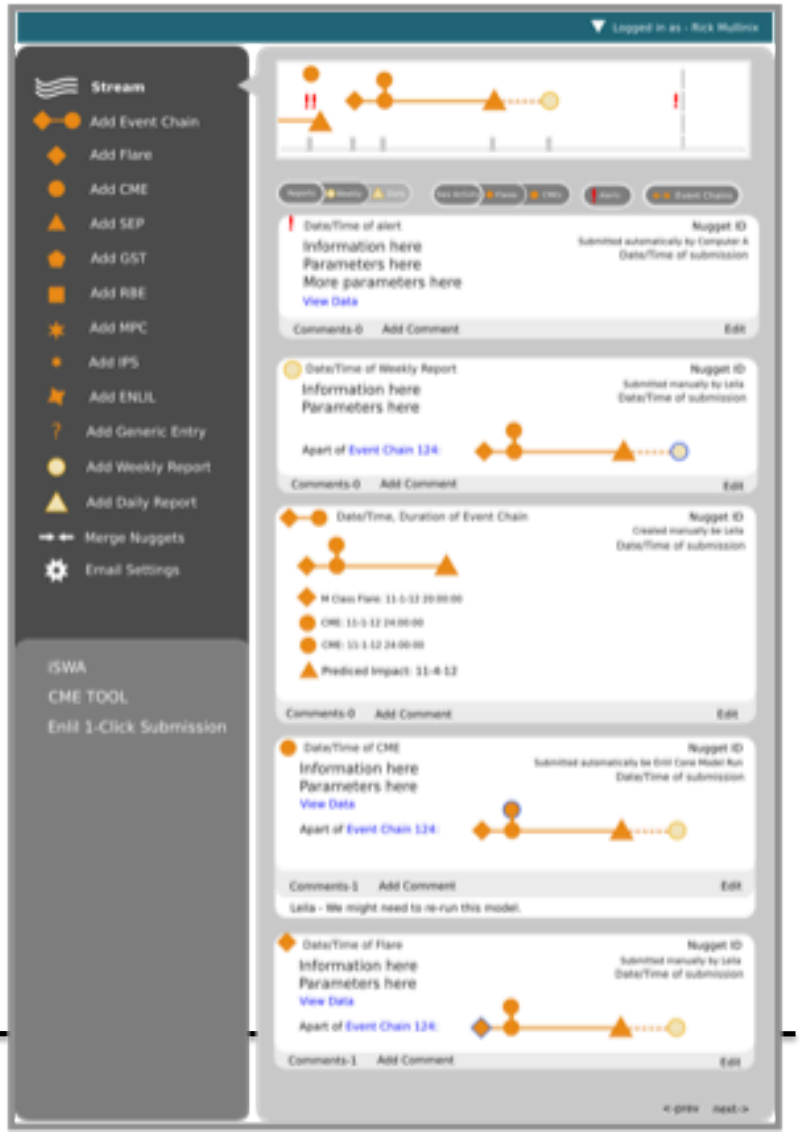
Powerful research tool/resource

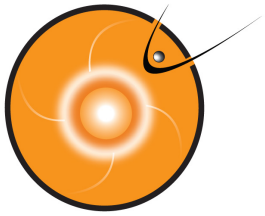
Space Weather Event Logging System

DONKI

- Forecasters log space weather events and activities
- Allow events/activity chains, establish cause and effect relationships
- Multi user/forecaster system designed to promote community involvement
- Entry point for initiating alerts, cataloging events
- Knowledge management system for human generated logs, analysis







Extras

CME cases

1. Start time of the event: 2013-03-15T06:54Z.

2. Start time of the event: 2013-03-05T04:24Z.
   04:40 for starting time – a difficult case
3. Starting time of 2013-05-03T18:00Z
   t1: 18:55, t2: 20:10
4. Starting time of 2011-03-07
   t1: 16:00, t2: 17:30 CME2: 20:45, 20:55
5. Starting time of 2013-04-24
   t1: 02:25, t2: 03:25
6. 2012-02-10
   t1: 21:55, t2: 00:10Z

Usage/Growth

January 2010 [TRL 6]	January 2012 [TRL 7/8]
iSWA Version **1.0**	iSWA Version **1.9.8**
171 Data Feeds	**370** Data Feeds
6 Million Data Files	**27** Million Data Files
135 SWx Products/Cygnets	**275** SWx Products/Cygnets
3K Visits (2008, 2009)	**170K** Visits (2010, 2011)
728 NASA Visits (2008,2009)	**10K** NASA Visits (2010, 2011)
671 Unique Visitors (2008, 2009)	**70K** Unique Visitors (2010, 2011)
0 twitter followers @NASAiSWA	**132** twitter followers @NASAiSWA

Usage & Statistics

Feb 12, 2012 – March 12, 2012

Visits

26,915

% of Total: **100.00% (26,915)**

Unique Visitors

12,717

% of Total: **100.00% (12,717)**

Timeline

Visits by Country

- **33.14% United States**
  8,920 Visits
- **17.24% Germany**
  4,642 Visits
- **5.35% Spain**
  1,442 Visits
- **3.19% France**
  861 Visits
- **3.10% United Kingdom**
  835 Visits
- **37.98% Other**
  10,215 Visits

Time on Page

990:29:23

% of Total: **100.00% (990:29:23)**

Spatial Scales

Spatial Scales

Ionosphere/Thermosphere: Spatial scale: km (< 1000 km)
Typical velocity: several 100 m/s

Magnetosphere: Spatial scale: 1 R_E (Earth's radius) = 6370 km
Typical velocity: several 100 km/s

Solar Corona: 1 R_S (solar radius) ~ 110 R_E

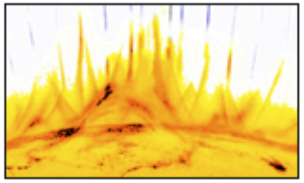
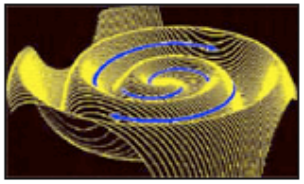
Heliosphere: 1 AU ~ 215 R_S

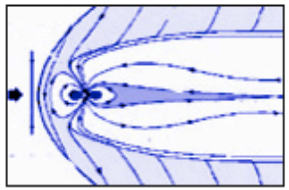
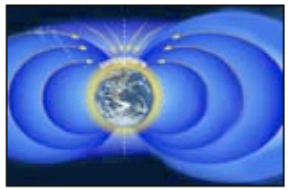
Request a Model Run

Request a Run

Runs on Request is a free service open to any scientist interested in running the **space weather models** hosted by the CCMC. If this is your first request for a model run, please take a look at how runs on request work and follow the Run Request Procedures for a particular model type (see table below). Models are also available for execution through **Instant Run** service.

Note: *For tracking purposes for our government sponsors, we ask that you notify the CCMC whenever you use CCMC results in scientific publications or presentations:* **Email CCMC**

Domain	Model Name	Model Developer(s)	Run Request Instructions	Run the Model
			Solar run instructions	
SOLAR 	MAS	J. Linker, Z. Mikic, R. Lionello, P. Riley	Generate input file for modeled run	Request A Run
	PFSS	J. Luhmann et al.	Solar run instructions	Request A Run
	SWMF/SC/IH	Tamas Gombosi et al.	Solar run instructions	Request A Run
	SWMF/SC/IH	Tamas Gombosi et al.	Solar run instructions	Request A Run
	ENLIL	D. Odstrcil	Helio run instructions	Request A Run
HELIOSPHERE 	ENLIL with Cone Model	D. Odstrcil	Helio run instructions	Request A Run
	Heliospheric Tomography	B. Jackson, P. Hick	Helio run instructions	Request A Run

MAGNETOSPHERE 	BATS-R-US	Dr. Tamas Gombosi et al.	Generate input data files and parameters	Request A Run
	SWMF/BATS-R-US with RCM	Tamas Gombosi et al., R. Wolf et al.	Magnetosphere run instructions Generate input data files and parameters	Request A Run
	OpenGGCM	Joachim Raeder, Timothy Fuller-Rowell	Magnetosphere run instructions Generate input data files and parameters	Request A Run
	Fok Ring Current	Mei-Ching H. Fok	Fok Ring Current model is driven by SWMF/BATSRUS output. To run, request a run for SWMF/BATSRUS and select 'Run M-C Fok Ring Current Model' at STEP 6.	Request SWMF/BATSRUS and select 'Run M-C Fok Ring Current Model' at STEP 6
IONOSPHERE 	SAMI2	Joseph Huba, Glenn Joyce, Marc Swisdak	Ionosphere run instructions	Request A Run
	CTIP	Timothy Fuller-Rowell et al	Ionosphere run instructions	Request A Run
	ABBYNormal	J. Vincent Eccles et al.	Ionosphere run instructions	Request A Run
	USU-GAIM	R.W. Schunk, L. Scherliess, J.J. Sojka, D.C. Thompson, L. Zhu	Ionosphere run instructions	Request A Run